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Graduate School of Management

Master in Public Administration

MODERN APPROACHES TO SOCIAL EFFECTS IDENTIFICATION FOR TRANSPORT INFRASTRUCTURE PROJECTS

Master's Thesis by the 2nd year student

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ЗАЯВЛЕНИЕ О САМОСТОЯТЕЛЬНОМ ХАРАКТЕРЕ ВЫПУСКНОЙ КВАЛИФИКАЦИОННОЙ РАБОТЫ

Я, Мурышкина Анжелика Игоревна, студентка второго курса магистратуры направления 38.04.04 «Государственное и муниципальное управление», заявляю, что в моей магистерской диссертации на тему «Современные подходы к идентификации социальных эффектов развития транспортной инфраструктуры», представленной в ГАК для публичной защиты, не содержится элементов плагиата.

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АННОТАЦИЯ

Автор	Мурышкина Анжелика Игоревна
Название ВКР	Современные подходы к идентификации социальных эффектов развития транспортной инфраструктуры
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Научный руководитель	Гиленко Евгений Валерьевич, доцент, к.э.н.
Описание цели, задач и основных результатов	Целью исследования является разработка модификации формулы оценки эффекта от сокращения временных затрат в проектах транспортной инфраструктуры. Задачи данной магистерской диссертации включают в себя детальный обзор литературы на тему социально-экономических эффектов и зарубежных методик для их определения с целью получения разнообразия методов идентификации социальных эффектов, а именно эффекта от сокращения временных; проведение опроса жителей деревни Кудрово, выбранной в качестве пилотной территории с наибольшим потенциалом к развитию транспортной инфраструктуры, с целью определения факторов, влияющих на восприятие времени, затрачиваемого в пути; обработка полученных данных путем анализа главных компонент с целью определения предпочтений по видам транспорта, возможным к реализации на территории и выявлению ключевых параметров, влияющих при выборе вида транспорта; обработка полученных данных с помощью кластерного анализа с целью определения наиболее значимых факторов, влияющих на восприятие времени; модификация формулы по оценке эффекта от сокращения временных затрат и дальнейшее тестирование полученной формулы с помощью имитационного моделирования методом Монте-Карло; На основе анализа зарубежной практики были выведены параметры, включаемые в формулу по оценке эффекта от сокращения временных затрат, однако результаты проведенного опроса показывают, что данные параметры не являются значимыми в изучаемой пилотной зоне. Наиболее значимым фактором для определения стоимости времени является комфорт. Косвенное определение данного параметра было включено в исследуемую формулу. Формула протестирована на стабильность и показала устойчивый результат. Результаты данного исследования могут быть использованы представителями как федеральных, так и региональных органов власти для оценки эффектов транспортных проектов.
Ключевые слова	Транспортная инфраструктура, социальные эффекты, эффект от сокращения временных затрат, анализ главных компонент, метод Монте-Карло

ABSTRACT

Master Student's Name	Anzhelika I. Muryshkina
Master Thesis Title	Modern Approaches to Identification of Social Effects of Transport Infrastructure Projects (the Case of Saint Petersburg)
Educational Program	Graduate School of Management, Saint-Petersburg State University
Main field of study	38.04.04 «State and municipal administration»
Year	2018
Academic Advisor's Name	Evgenii V. Gilenko, associate professor, PhD in economics
Description of the goal, tasks and main results	The goal of the research is to introduce an improved approach for assessing value of travel time savings (VTTS) after implementation of transportation infrastructure projects. The objectives of this master's thesis include a detailed literature review on socio-economic effects and foreign methods for their identification aimed at obtaining a variety of methods for identifying social effects, namely VTTS; conducting a survey of residents of Kudrovo village, chosen as a pilot area with the greatest potential for the transport infrastructure development, in order to identify factors that affect the perception of the travel time; data processing with Principal Component Analysis in order to determine the preferences of respondents and identification of key parameters that affect the choice of mode of transportation; data processing with cluster analysis in order to determine the most significant factors influencing the perception of time; modification of the formula for assessing VTTS and further testing the modified formula using Monte Carlo imitation modelling; On the basis of the analysis of foreign practice, the parameters included in the formula for estimating VTTS were derived, but the results of the survey show that these parameters are not significant in the studied pilot zone. The most significant factor for determining the cost of time is comfort. Indirect definition of this parameter was included in the investigated formula. The formula was tested and showed a stable result. The results of this study can be used by representatives of both federal and regional authorities to assess the effects of transport projects.
Keywords	value of time travel savings; social effects; transportation infrastructure projects; principal components analysis; Monte-Carlo simulations

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Introduction

Transport infrastructure development has been proven to play a key role in economic growth of the area, where the transport projects are constructed. The figure 1 shows interconnections between transportation investments and interventions and economic development. Social and economic impacts influence social and economic wellbeing, which directly influence economic development of the area. The impacts can be both positive and negative and thus it is important to evaluate as many effects as possible to predict the potential outcomes of the economic development (Leung, 2006). Transport infrastructure assessment and rational choice of projects to be implemented is a critical issue. Especially when it comes to mega-projects that require profound financial state support, commercial profit is hard to extract from these projects, thus socio-economic outcomes should be calculated.

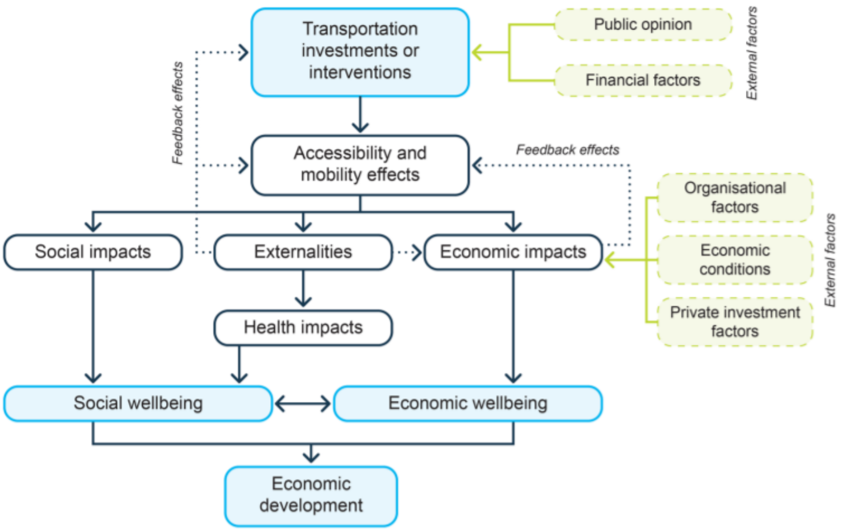


Figure 1Transport and economic development - key connections (Leung, 2006)

Figure 2 poses spheres that have to be analyzed before implementing transport policy measures. As each transport infrastructure project is aimed at improving transport system in the area, the area itself must be analyzed and checked for adequacy of the planned project.

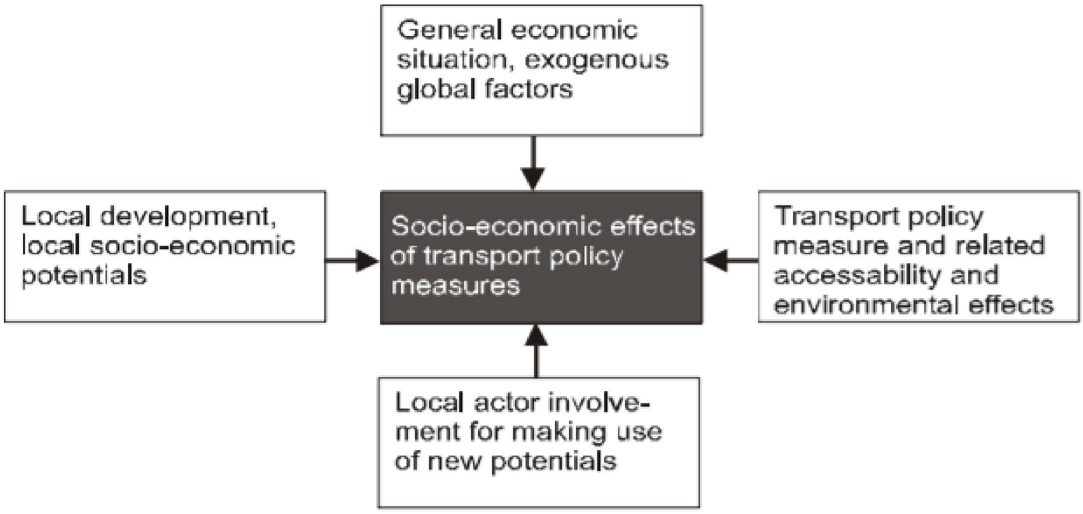


Figure 2 Systems of analysis of relevance of transport policy measures for socio-economic development (Department for transport, 2005)

Such spheres as local development and socio-economic potential of the area should be questioned; general economic situation as well as exogenous global factors are examined, so it is important to be aware of the context like general investment climate, which directly influences demand for land use development. Political aspect is also important in case of different municipalities involved in the process it is extremely valuable to know whether all the stakeholders are ready to implement the project and find compromises in questionable situations (Department for transport, 2005).

Ashauer (1989), Nadiri (1990) proved that transport infrastructure projects influence positively on production. Vikerman (2007), Lakshmanan (2011) and Weisbrod (2009) combined and aggregated all the previous researches in this filed. Lakshmanan (2011) depicts three research directions: microeconomic analysis, macroeconomic analysis and research on wider economic benefits. Vikerman (2007) proposes similar directions: microeconomic, macroeconomic and market analysis. Weisbrod (2009) states there are 3 shapes of multiplier effect on territory development: direct, indirect and other social effects Combination of those scientific works provides several levels of effects: the first level is connected to direct user benefits, those are transport effects that are calculated nowadays in order to assess the economic effect. The second level implies wider economic effects; those are closely connected with transport field and are also calculated. Both first two levels can be transformed into monetary form and that is why methodologies exist that allow calculating these parameters and assessing economic effect. The more difficult task concerns the third level of agglomeration effects, social effects and outcomes of the transport infrastructure development. The article also implies that this level of benefits stimulates increase in population wealth (Koncheva, 2015).

The current situation in many urban districts is that growing number of real estate causes traffic congestion. Developers are not interested in providing social and economic infrastructure. The main driver for their activities is profit. Thus, the more square meters are built and sold the more money developer gets. Stakeholder that is responsible for providing all necessary infrastructure is government. However, local governments do not have enough financial and time resources to provide all municipalities with required infrastructure conditions. As the result, houses are built, roads are absent. For almost each district is possible to implement several transport infrastructure projects: automobile roads, roads for public transport, subways, train railways, tram railways. What is important in these situations is to make rational decision on what project to implement. In order to do this prior analysis of project effectiveness is required.

The more carefully all socio-economic effects are calculated, the more effective will be decision on which project should be realized as the first priority. Currently almost 80% of each project assessment takes travel time savings. This is the major impact of any transport project. The current methodology in Russia takes into account travel time reduction and monetary coefficient which is calculated either through GDP or GRP. Another option is to consider average salaries in region or country as a whole. This information does not provide clear understanding of who are the users, what they prefer, what are probabilities that car owners will switch to public transport in case of better public transport infrastructure. This methodology also does not provide information on how people value their time and what trip purposes are more ‘expensive’ for them and which are less.

In order to provide recommendations for state authorities for a more detailed analysis of every transport project, the research is held in this sphere. The **goal** of the research is to introduce an improved approach for assessing values of travel time savings after implementation of transport projects. The following objectives take place in order to reach the set goal:

1. Analyze foreign VTTS (value of travel time savings) methodologies and collect information on what personal information about the users s take n into account when assessing transport projects effectiveness;
2. Analyze Russian methodology in order to understand what factors are included in the formula for VTTS assessment and what factors are omitted for which reasons;

3. Conduct survey in order to extract citizens' preferences on transportation mode choices. The survey contains 9 questions of preferences that connect value of time and other parameters such as comfort, safety, ecological concern, prestige. This will allows to extract situations when people evaluate their time more and less and what is the cost they are ready to pay for travel time reduction;
4. Extract the most influential features for all groups of citizens and use them to construct logistic regression with binary choice of switching from car to public transport. This will allow to come to one feature that can be included in the official formula of VTTS calculation
5. Update the existing formula with selected feature and test it by Monte-Carlo method. This will allow to check stability of the model and mitigate risks of outliers under certain conditions.
6. Carry out a set of recommendations for the state authorities to improve the existing methodology and for local authorities to prioritize the projects to be implemented.

This work aims to answer the following research questions:

1. How do Russian people value their travel time?
2. What are the key features that influence people's choice of mode of transportation?
3. How can this knowledge be reflected in the formula of value of travel time savings?

In the research primary data was used, particularly a questionnaire created according to features of various transport modes. The research was held online and offline. The offline survey also included interview to find out how people live in Kudrovo and what infrastructure they need and what is their lifestyle. As well as getting to know people from this district pre-test of the questionnaire was done. Interviewees were asked whether they understood all questions in the proper way and which questions should be further improved. The first version of the questionnaire contained 22 questions and after pre-testing it was shortened up to 18 questions.

This paper consists of three chapters. The **first chapter** is dedicated to the current situation. It will present definitions that are to be further used in the research, current legislation on transport project effectiveness assessment and statistical information on road system development in Russian cities and European cities. The **second chapter** introduces analysis of foreign and Russian methodologies on value of travel time savings assessment, as well as comparison of factors that are included in the methodology. The third part is dedicated to the empirical part of the research with data description and steps of the empirical analysis as well as presentation of results of the research.

Chapter 1. State-of-the Art of socio-economic effects of transport infrastructure

1.1. Background

1.1.1. Terminology

Infrastructure has a wide range of definitions and in general it is difficult to address it to a particular object. Generally, infrastructure implies basic public infrastructure forming the foundation for society and economics. Calderón, C., & Servén, L. (2004) depicts infrastructure as an umbrella term for a variety of activities, which plays a very important role for industrial and overall economy. There are two types of infrastructure according to various economists: economic infrastructure and social infrastructure. Promoting economic activity infrastructure, such as roads, highways, railroads, airports, sea ports, electricity, telecommunications, water supply and sanitation define **economic infrastructure**, whereas promoting health, education and cultural standards of population including schools, libraries, universities, clinics, hospitals, courts, museums, theatres, playgrounds, parks, fountains and statues) define **social infrastructure** (Fourie, 2006).

Each transport infrastructure project requires prior assessment in order to make a decision on whether to implement it or not. In these terms, it does not differ from any other investment projects, so it has the same general features. One of them is efficiency assessment. **Efficiency assessment** implies degree to which its results are consistent with the goals and interests of stakeholders, such as society, investors, shareholders, creditors, officials. Efficiency assessment contains three types: **public efficiency**, **commercial effectiveness** and **budget effectiveness** (Dinges, 2016, p.6-7). Each type of effectiveness identifies efficiency, characterized by comparing activity results and costs, required for accomplishing the expected result (Sabirov, 2011).

If transport infrastructure projects need non-budgetary financing, commercial effectiveness is assessed. **Commercial effectiveness** implies financial outcomes for particular participants of the project, i.e. investors. This type of efficiency considers only financial indicators of investment, for instance profitability, NPV and etc (Sabirov, 2011, Dinges, 2016). **Budget effectiveness** considers financial consequences for federal, regional or local budget and identifies necessity of state participation in terms of budget investments. It characterizes profits of federal, regional or municipal budget from tax incomes, appeared after project realization (Sabirov, 2011) **Public efficiency** assesses socio-economic impact of project implementation for society as a whole. All projects of road construction or reconstruction require public efficiency assessment. Definition of public efficiency of the road project is made by comparing the social (national economic) costs and results that will occur in transport and in non-transport branches of the national economy in case of the project (project version), with those costs and results that will occur if the project is not implemented (basic version) (Dinges, 2016, p.6-7).

Socio-economic effectiveness implies summation of all economic effects from transport project implementation and social effects that will occur in case of project implementation. Social effectiveness reflects social results and can be expressed as wealth increase of population or demographic indicators change. Economic effectiveness takes into account all benefits and costs, including those, which occur broader than economic interests of stakeholders. Among those benefits are indirect and wider economic effects.

Distinguishing between purely economic and purely social effects is a difficult task, as many researches defined overlapping of features of both classes of effects (Markovich, 2011). The general consideration about **social effects** is that these are ... “changes in transport sources that (might) positively or negatively influence the preferences, well-being, behavior or perception of individuals, groups, social categories and society in general (in the future)” (Geurs et al., 2009). Consequently, economic and environmental issues are strongly connected and interrelated to social effects of infrastructure projects. In order to distinguish between the groups some researches suggest two broader categorizations of social impacts: those that are derived from the provision of transport, such as infrastructure, vehicles, facilities and activities, and others that are derived from user experience, i.e. experience of travel, being in traffic (Geurs et al., 2009).

Direct and indirect effects can both occur in economic and social sphere, but mostly they are distinguished in economic block of effects. The **direct effects** are those that occur near a street or a highway or other transport infrastructure objects. The **indirect effects** are any impacts that occur in locations more distant from the object itself. It also includes influence on other spheres of economic activity, not connected to new transport objects (Boarnet, 1996).

Another aspect of transport infrastructure assessment is techniques that are used for assessment. Two widely spread of them are **Cost-Benefit analysis** (CBA) and **Multicriteria analysis** (MCA). Cost-Benefit Analysis compares costs and benefits of an alternative and uses monetary values to measure all the effects. The major problem of this technique is that it is impossible to take into account those effects that are not in monetary form, thus most of environmental and social effects must be omitted. The Multicriteria Analysis evaluates simultaneously the achievement of some objectives by quantifying both impacts, quantitative and qualitative, not necessarily in monetary terms. The drawback of this method is presence of subjectivity on behalf of usage of non-monetary indicators (Cascajo, 2005).

1.1.2. Classification of socioeconomic effects in transport infrastructure and methodologies

Socio-economic effects are those outputs and outcomes that do not directly consider the road network or building of subway station. These effects appear when the project is implemented and influence either economic situation of the area or social environment. These effects are important because only they play key role when deciding on project implementation. Almost no transport infrastructure project can bring profit to Government directly. Commercial and budget efficiency are usually negative. The project does not create financial profit. The real effect is that economy starts developing faster and social services become more accessible for population. Therefore, neglecting social and economic effects is impossible and in order to get objective vision of public utility after any transport project implementation, it is worth knowing what kind of effects exist and what resources are required in order to assess these effects.

All kinds of socio-economic effects resulting from the construction (reconstruction) of highways can be divided into three groups presented in table 1.

Table 1

Socio-economic effects (Dinges, 2016)

№	Characteristics	Examples
1	• calculation is based on known functional dependencies • do not depend on the specific conditions for the implementation of road projects • do not require the collection of generally inaccessible additional information on conditions their manifestations • well-tried in practice	**transport** - reduction of capital investments in motor transport due to reduction of delivery time of cargoes and passengers; - cost reduction of transporting goods and passengers as a result of improved road conditions; **other industries** - reducing the loss of transit time for passengers; - reduction of the needs of enterprises and organizations in working capital;

		- reduction of losses from road accidents
2	• based on empirical (statistical) dependencies • strictly defined fields of application • requires carrying out (in order to obtain the necessary initial data) rather complicated technical and economic research in the area of gravity to the projected road structure • each of the effects of the second group is recommended to be taken into account in the presence of the following three conditions: 1) the reliability of the initial data for its determination is beyond doubt; 2) the initial data for calculating the effect are within the scope of the regression equation constructed for its determination; 3) the significance of the effect is quite high (the share of each of the effects is in the total value of not less than 5%).	**transport** - the effect of switching part of the transportation of goods and passengers, previously carried out by rail and water transport, to road transport; - profits of road transport organizations from the implementation of additional transport (in connection with the transfer of their part from the railway and water transport to the automobile); **other industries** - accelerated development of the branches of material production; -developing new natural resources and developing new industries; - reduction of losses in agriculture; - health effects; - effect in the sphere of public services for the population; - effect in the sphere of trade relations; - losses from deterioration of the ecological situation; - losses from temporary withdrawal of agricultural lands for placing on them the objects of the production base of construction and offshore quarries.
3	requires special statistical studies at the macro level, due to synergetic impact on the economic potential of the region	- the multiplier effect (the effect of increasing the gross regional product); - economic effect in agriculture; - economic effect in the sphere of trade;

		- economic effect in the sphere of improving the investment climate; - social impact in the healthcare sector; - social effect in the area of improving the well-being of the population

Calculation of first two groups of effects is widely spread not only in Russia, but in foreign countries as well. The most frequently applied methodology is cost-benefit analysis (CBA). However there are other alternatives for socio-economic effects assessment. Apart from CBA they are not as widely spread, as the main difference that these methodologies do not allow financial estimations. When it comes to costs of project implementation state authorities are interested in monetary payback. Nevertheless, it is also important to understand what other procedures are available and how they differ from CBA.

World practice of project assessment uses 4 major methods:

1. Cost-effectiveness analysis (CEA)
2. Cost-utility analysis (CUA)
3. Weighted cost-effectiveness analysis (WCEA)
4. Cost-benefit analysis (CBA)

As it can be seen from the table, each method has specifics and can be used in a particular situation, however the complete picture of the project is got from all the methods being used.

Table 2

Methodologies to assess socio-economic effects (Alaev, 2015)

Name	Specifics of usage	Advantages	Disadvantages
CBA	Allows to assess projects in terms of NPV	Can be used in financial models as results are in monetary units	Ignores non-monetary effects
CEA	Costs are calculated in both monetary and normal units, benefits are calculated only in normal units or as indicators, which identify goal of project	Includes not only effectiveness, but also productivity and efficiency	Does not imply comparison of the results

	implementation and industry specifics		
CUA	Compares costs (calculated in monetary form) and public utility (calculated in utility units)	Relative coefficients allow to assess the specifics of the project and public utility	Low objectiveness of the results Practical problems with coefficient defining and calculation
WCEA	Used when effects cannot be calculated in monetary units and can lead to different results	Allows to weight various social effects from project implementation	Subjective coefficient significance definition for various effects

All socio-economic effects can be divided into three major groups according to their characteristics. Direct effects are those that are strongly connected to the direct usage of the road network or other transportation project. Indirect effects are connected to other spheres of public life like healthcare, unemployment, economy development, education. This means that transport infrastructure projects creates conditions for effects in other industries can occur. The first group of effects can be easily assessed as there are formulas and open data. These two conditions are extremely important. Moreover, all of these effects can be transformed in monetary form, which allows to include them in CBA.

The second group of effects has several limitations. Such conditions as existing open data, possibility of holding research in the area of gravity of project are obligatory. There are no prior formulas that can be used, thus reliability of the results must satisfy at least 5% significance level. The third group contains one of the most valuable but very hard to quantify multiplier effect, which is effect of GRP or GDP after project implementation, and overall effect on other industries' development. This group requires specific statistical studies at the macro level and constructing complex model for estimation. The biggest challenge in this sphere is data collection.

Methodologies represent 4 approaches, two of which are the most widely spread. They are CBA and WCEA. The first one is more preferable due to allowing transformation of effects in monetary form. However, its limitations are that not all social effects can be assessed under this methodology. CEA does not own this limitation, but its results cannot be compared for several projects, thus it makes impossible to choose between several alternatives.

Cost-utility analysis and weighted cost-effectiveness analysis allow to measure unmeasurable social effects, but both are subjective, that's why they are not that widely spread.

1.1.3. Russian legislation, state methodologies of effects assessment

Russian project assessment is based on several official documents that regulate assessment.

1. Decree of the Government of Russian Federation from 30 December 2011. № 1206 «on the Procedure for the Formation and Use of Budgetary Appropriations of the Federal Road Fund and on Amending the Rules for the Formation and Implementation of the Federal Targeted Investment Program».

Resolution states the rules for capital investments in road construction and reconstruction; provision of the necessary facilities aimed at increasing safety of roads; subsidizing of state company "ROSAVTODOR". The resolution does not indicate rules for project assessment.

2. Order of the Ministry of transportation of Russian Federation from 01 August, 2016, № 221 «on approval of the methodology for selecting projects for the construction (reconstruction) of highways (sections of highways and (or) artificial road structures), implemented by the subjects of the Russian Federation in the framework of concession agreements, for the provision of other interbudgetary transfers in order to achieve the target indicators of regional programs in the road sector, providing for the implementation of these projects»

The methodology states general requirements for selecting procedure of concession projects, including: requirements to projects; list of documents necessary to be provided; the procedure for calculating an integrated evaluation of a regional concession project; deadlines for reporting; and other requirements for projects of this type.

3. Decree of the Ministry of Region of Russian Federation from 30 October, 2009 №493 « On the approval of the methodology for calculating indicators and applying the criteria for the effectiveness of regional investment projects that claim to receive state support from the budgetary appropriations of the Investment Fund of the Russian Federation».

The methodology states the list of effectiveness indicators for regional investment projects including financial efficiency, budgetary efficiency, social effects. Social effects introduced in the document include:

a) increase in the level of employment of the population at working age;
b) increase of the level of provision of the population with comfortable housing;
c) improvement of the environment;
d) increase of accessibility and quality of services to the population in the sphere of transport, health, education, physical culture and sports, culture, housing and communal services.

The document however does not provide information on required calculations for social effects. It only presents formulas for financial efficiency, economic indicator and budgetary efficiency. It also requires the projects to satisfy the goals of socio-economic development, based on regional strategies; however, there is no indicator that allows to estimate how much the project corresponds to the strategic directions.

4. Decree of the Ministry of Economic Development of Russian Federation from 31 July, 2008 №117 «On the approval of the methodology for calculating indicators and applying the criteria for the effectiveness of regional investment projects»

The Decree partially contains information from the previous document and identifies criteria for effectiveness assessment of different types. As well, it provides formulas for some of the indicators, including financial, budgetary and economic indicators. Economic efficiency is defined by integral indicator, which characterizes a part of the total for all years of the calculation period of the projected real volume of the gross regional product, which can be provided by the implementation of the investment project. Particularly it estimates differences in indices of economic development for base conditions and conditions under project realization.

The document does not contain information on social effects estimation as well as environmental impacts and direct economic effects of project realization. This only states the necessity of project funding for federal ministries, when it is already approved that the project is to be implemented and there is a need in extra financing from the federal budget.

Decree of the Government of Russian Federation from 5 November 2013. No 991 «On the procedure for assessing the appropriateness of financing investment projects at the expense of the National Wealth Fund and (or) pension savings in the trust management of the state management company, on a return basis»,

5. Order of the Ministry of Economic Development of the Russian Federation of February 24, 2009 No 58 «On Approval of the Methodology for Evaluating the Efficiency of Using the Federal Budget Funds for Capital Investments»

The order states methodology for evaluating the efficiency for capital investments. It introduces the system of indicators which correspond to requirements to projects. Capital investments presented from various spheres of both social and economic infrastructure. Quantitative indicators to road infrastructure listed in the Order are as follows:

- Amount of jobs created, units
- Volume, increase in the volume of freight turnover of transport, passenger-km per year
- Reduction of the time *en route* of goods, passenger, %
- An increase in the percentage of settlements connected by hard-surfaced roads to the public communication network

However, the methodology still does not indicate which formulas to use in order to calculate the listed indicators. It only contains information on what amount of points under which conditions should various efficiency factors get.

6. The only document that provides information on socio-economic effects assessment is Guideline on efficiency assessment of construction, reconstruction, capital repair and renovation of automobile roads issued by ROSAVTODOR. This document was elaborated by Moscow automobile and road state technical university in 2015 and issued due to Order from 10, November, 2015 «2106-р». This guideline is not an obligatory document, thus it can only recommend which methods to choose and use in order to assess various types of efficiency for project assessment.

Guideline introduces goals and objectives of efficiency assessment, types of effectiveness and particular indicators including formulas for their estimation. All transportation projects that are primarily assessed use this guideline as basis for analysis. To conclude, there are no other universal methodologies that set rules and regulations for socio-economic efficiency assessment.

All listed documents provide foundation for companies that work with transport infrastructure to prepare documentation for further project implementation. However, none of these documents present clear algorithm of choosing between alternatives of different projects.

None of these documents clarifies what project should be implemented in the first run. As well as none of these documents provides information on how complex of transport projects should be assessed together. It is obvious that if there is a whole complex of roads, tunnels, intersections it is not enough to sum effects up and get results. There must a particular algorithm how to combine those objects and calculate conjoint effects from their realization.

1.2. Statistical overview

1.2.1. Road infrastructure in Moscow

Moscow is the capital of Russian Federation. It is not only the official capital being a residence for State authorities; it is also a financial center of the country. City population is constantly rising yearly. People from all over the country come to Moscow seeking for better working and living conditions, more opportunities and in general a wealthier life. Picture 3 depicts tendency of growing population. In 2017 official statistics fixed 12380,7 thousands of officially registered citizens.

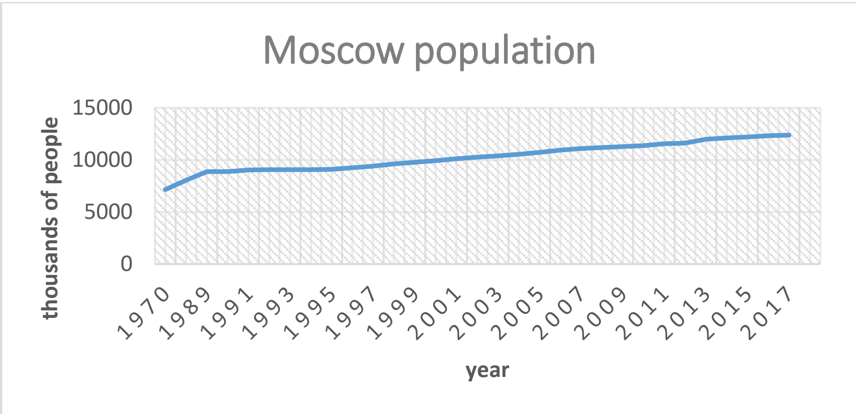


Figure 3 Moscow population (Rosstat, 2018)

Certainly rising amount of citizens negatively influences transport infrastructure capacity. According to the State Traffic Safety Inspectorate in 2017 in Moscow, the number of registered cars is approximately 5.6 million. It is worth noting that annually in Moscow it is 8-10% more cars. Yearly statistics depicts that every year in Moscow 350-400 thousand vehicles are registered. The active increase in the number of cars began in the mid-90s. For example, in 1950,there were 82 thousand vehicles, in 1960 - 150 thousand, in 1970 - 500 thousand (Karyakin, 2018).

The number of cars in Moscow directly affects level of congestion. According to experts at the same time on the roads of Moscow, more than 700 thousand cars start moving, and for traffic without traffic jams, the number of vehicles should not exceed the mark of 400 thousand cars However, Moscow is not even in top 10 busiest cities with traffic (Karyakin, 2018).

Global network that evaluates level of congestion worldwide shows that every day drivers spend extra 49 min, which being calculated in yearly time is about 189 hours, on commuting in congested traffic. Morning peaks exceed non-traffic time at 71%, whereas evening peaks reach up to 94%. Increase in overall travel time when compared to free-flow congested situation is about 44% extra time (Tomtom traffic index, 2018).

From 2008 to 2012, a steady increase in the Moscow Tomtom travel time index (TTTI) was observed from 46 to 57% (+11%). After 2012, the TTTI has consistently been decreasing at an average reduction of 4.3% per year, and in 2015 reached pre-2008 Traffic Index levels (44% in 2015). This decrease is concurrent with the implementation of Moscow's information technologies system (ITS) programme which was launched in 2012. The city's ITS infrastructure implementation was completed at the beginning of 2015, the year that faced the biggest reduction in Traffic Index from the previous year (-6%). The ITS programme includes traffic sensors, CCTV cameras, traffic signal control systems and public transport management systems. During the same period, Moscow made extensive investment into public transport. Additionally, the City implemented an advanced parking management system across Moscow, which is reported to have reduced the time spent searching for parking by 65%, having a significant effect on reducing congestion.(Tomtom traffic index, 2018).

For the last 7 years the length of the Moscow roads has increased by 16%. Currently the length of Moscow's roads is 3,600 km, while the availability of the Russian capital by the road network is two to three times lower than that of any other metropolis in the world. On average, the area of the territory of Moscow, which is occupied by roads, is only 8%, on the periphery the indicators are reduced to 2 - 3% at the European rate of 15-20%. There are plans on constructions of 3 chords that will connect different parts of the city and allow to increase average speed of traffic (Road construction, 2018). As well as this every year several new metro stations are constructed and public transport network improves. City invests financial resources on parking conditions improvement which also allows to decrease congestion level and decrease amount of parked cars in the city center

Another significant factor in the development of the city's road network, in addition to global megaprojects on the takeoff and chord lines, is the construction of small local roads in different districts of Moscow. The fragmented nature of Moscow's roads, especially in peripheral areas, generates the problem of a huge rerun. Since the construction of the Third

Ring Road in the city, no measures have been taken to improve road connectivity (Road construction, 2018).

Although Moscow undergoes problems with traffic congestion and lack of roads connectivity and parking spaces for all cars and continuing growth of city, it is important to mention that city yearly invests money in development of transportation system, not only reconstructing existing roads. This is possible due to an effective distribution of financial resources and correct urban policy, chosen by the authorities.

1.2.2. Road infrastructure in Saint-Petersburg and Leningrad Region

Saint-Petersburg is not only a cultural capital of Russian Federation, it is also one of the most developed regions in the country. In 2016 Saint-Petersburg took the second place in the rating of regions by their socio-economic development, compared to 2015, when it was also second (Rating, 2016). Index of quality of urban environment shows that the city has satisfactory situation with development of urban environment, particularly it got 66% for street infrastructure, within this block of grades, ecology and modernity of environment got the lowest points (Index of quality…,2018).

The city population is increasing yearly since 2009 and is predicted to grow in the future as it is shown in table 1. The opportunities for the city to grow physically as it happened with Moscow are not that possible, due to closeness with Leningrad region. The tendency now however is that more and more apartment complexes are built in municipalities of Leningrad region that are close to Saint-Petersburg.

Table 3

Predicted city population

Year	Thousands of people
2015	6111,2
2028	7380,0
2038	8000,0

Among these municipalities are Vsevolozhskiy, Gatchinskiy, Lomonosovskiy, Tosnenskiy, Kirovskiy districts and Sosnoviy Bor. In 2015 Saint-Petersburg started to elaborate conjoint transport strategy of agglomeration with Leningrad region as well as the concept of joint urban development of St. Petersburg and the territories of the Leningrad Region (agglomeration) (Администрация Санкт-Петербурга,2018). These two concepts imply conjoint development of adjacent territories and transportation system within those territories.

Road system of Saint-Petersburg without considering Leningrad region undergoes difficulties with congestions as road network is far behind level of auto mobilization in the city. Global traffic index states that every day citizens spend extra 47 min for commuting, which equals 179 hours per year. During morning peaks, there is an increase in travel time at 65%, whereas during evening peaks this coefficient raises up to 90% of extra time compared to free-flow situation (TomTom traffic…,2018).

According to statistics provided by (TomTom traffic…,2018) the level of congestion in Saint-Petersburg remains stable since 2008 to 2016. The graph shows that there are small disturbances and from year to year extra travel time either increases or falls insignificantly. The visual tendency, however, is that still congestion level slowly decreases. It can be connected to launch of Ring highway, which was fully opened in 2011 and it significantly helped to decrease amount of transit cars within the city.

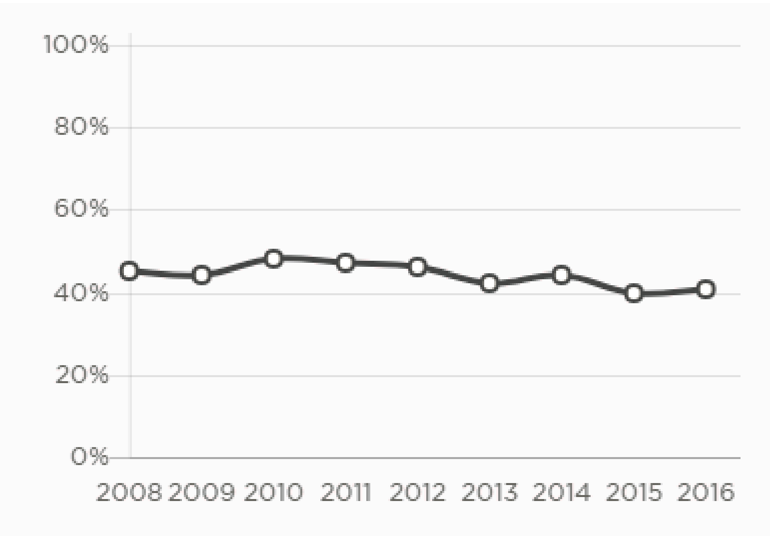


Figure 4 Congested level history (extra travel time) (TomTom Index, 2018)

The conception of transport infrastructure development from 2017 to 2038 years aims at solving the following problems that exist in Saint-Petersburg:

1. High travel time costs due to low speed of public transport, and high congestion level
2. Low level of public transport comfort due to big intervals between transport, overload of public transport within peak hours, not optimal route network
3. Private car parking problems due to lack of slots for permanent storage, deficit of temporary parkings

4. Non-safety of transportation complex due to high amount of car accidents and negative environmental externalities

In order to solve the listed problems certain measures of construction of new roads, highways, underground stations and speed trams are implied. As for the final indicators of effectiveness by 2038 the concept states 21% increase of speed of traffic on the road network within the city, 35% increase of speed of public transport and consequently 6% decrease of travel time by public transport, 23% share increase of tram and underground transportation(Администрация Санкт-Петербурга,2018).

1.2.3. Road infrastructure in big European cities

The European Union states transport industry as one of the key sectors of economy. It not only provides citizens with necessary infrastructure for more convenient transportation, but also sustains more than 11 million job places and majorly contributes to the economy. Among states challenges there is congestion which costs European countries around 1% of annual GDP, uneven infrastructure around countries, greenhouse gas emission as well as oil dependency (EU transport policy, 2018).

Germany is one of the leading countries in EU also faces challenges with transport infrastructure. Table 4 presents transport analysis for 4 biggest cities in Germany: Berlin, Hamburg, Munich and Cologne.

Table 4

Congestion level in German cities (TomTom Index, 2018)

	Berlin	Hamburg	Munich	Cologne
Congestion level (extra travel time, %)	29	33	30	34
Extra travel time, min per day	28	30	31	34
Extra travel time, hours per year	107	116	119	130
Morning peak, % of extra time compared to free-flow traffic	43	48	51	52
Evening peak, % of extra time compared to free-flow traffic	50	53	53	61

The table shows that in Berlin level of congestions is much lower than in other cities, which saves up to 13 extra hours. Although these high yearly savings come from small time saving within one day, several minutes in long-run change into several hours. However, the dynamics of all 4 cities shows that congestion level keeps rising since 2009. The speed of increase is not very high, but the tendency is still upward.

French capital also undergoes growth of congestion level, in 2016 it was 36% extra travel time, compared to 2015 when it was 34%. Statistically, every day commuters spend extra 40 minutes which in the long run turns into 154 hours per year. Morning peaks are almost at the same level as evening peaks, being around 65% of extra time compared to free-flow traffic (TomTom traffic…,2018).

Barcelona has a better situation with congestion level, compared to France, and almost the same level as German cities. Citizens, with 51% during morning peaks and 52% during evening peaks, spend, on average, 31% of extra travel time. Every day they spend 31 minutes extra, which is 119 hours per year (TomTom traffic…,2018).

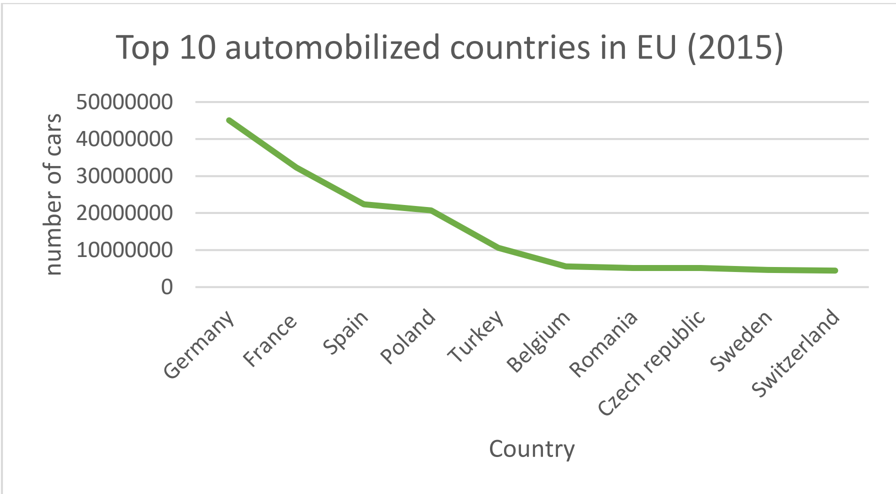


Figure 5 Top 10 automobilized EU countries (Passenger cars in EU, 2018)

Figure 5 shows that only 4 countries have more than 20 mln cars according to latest statistics of 2015 which means that the major transport infrastructure investments must be allocated in countries like Germany, Spain, France and Poland. Based on statistics of 2014 in Italy there were 37 mln of cars, but data for 2015 is not presented. However, it can be implied that Italy is also among those countries with high necessity in transport investments (Passenger cars in EU, 2018).

Milan has about 30% of extra travel time with harsh morning and evening peaks at 60% extra travel time. Whereas Rome is has one of the worst situations and having 40% extra travel time and more than 40 minutes of extra time which yearly gives 163 hours. Morning and evening peaks increase travel time up to 70%. Compared to other cities Rome has the closest numbers with Moscow and Saint-Petersburg (TomTom traffic…,2018).

The overall tendency of European transport policy is majorly connected with decrease in number of accidents, environmental improvements and overall transport system improvement. Number of private cars keeps on rising and the same issues as in Russia are in concern. Among them are highways, transfer roads, parking places. Among analyzed cities Rome is closer than any other to Russian megacities and thus it should be further analyzed what measures are taken by authorities in order to improve the situation in the city.

1.3 Summary of Chapter 1

Infrastructure is a variety of activities that play a very important role for industrial and overall economy. It is divided into two classes: economic and social. The first type promotes economic activity, whereas the second promotes promoting health, education and cultural standards of population. Transport projects represent the first class of economic infrastructure.

Each transport infrastructure project requires prior assessment in order to make a decision on whether to implement it or not. In these terms, it does not differ from any other investment projects, so it has the same general features. One of them is efficiency assessment. Efficiency assessment implies degree to which its results are consistent with the goals and interests of stakeholders, such as society, investors, shareholders, creditors, officials. Efficiency assessment contains three types: public efficiency, commercial effectiveness and budget effectiveness (Dinges, 2016, p.6-7).

For this research, public efficiency plays crucial role, which assesses socio-economic impact of project implementation for society as a whole. Socio-economic effectiveness implies summation of all economic effects from transport project implementation and social effects that will occur in case of project implementation. Social effectiveness reflects social results and can be expressed as wealth increase of population or demographic indicators change. Economic effectiveness takes into account all benefits and costs, including those, which occur broader than economic interests of stakeholders. Among those benefits are indirect and wider economic effects.

The general consideration about social effects is that these are ... “changes in transport sources that (might) positively or negatively influence the preferences, well-being, behavior or perception of individuals, groups, social categories and society in general (in the future)” (Geurs et al., 2009).

All socio-economic effects can be divided into three major groups according to their characteristics. Direct effects are those that are strongly connected to the direct usage of the road network or other transportation project. Indirect effects are connected to other spheres of public life like healthcare, unemployment, economy development, education. This means that transport infrastructure projects creates conditions for effects in other industries can occur. The first group of effects can be easily assessed as there are formulas and open data. These two conditions are extremely important. Moreover, all of these effects can be transformed in monetary form, which allows to include them in CBA.

The second group of effects has several limitations. Such conditions as existing open data, possibility of holding research in the area of gravity of project are obligatory. There are no prior formulas that can be used, thus reliability of the results must satisfy at least 5% significance level. The third group contains one of the most valuable but very hard to quantify multiplier effect, which is effect of GRP or GDP after project implementation, and overall effect on other industries' development. This group requires specific statistical studies at the macro level and constructing complex model for estimation. The biggest challenge in this sphere is data collection.

Russian methodology basis for public efficiency is presented by 5 documents. All of them provide foundation for companies that work with transport infrastructure to prepare documentation for further project implementation. However, none of these documents present clear algorithm of choosing between alternatives of different projects. None of these documents clarifies what project should be implemented in the first run. As well as none of these documents provides information on how complex of transport projects should be assessed together. It is obvious that if there is a whole complex of roads, tunnels, intersections it is not enough to sum effects up and get results. There must a particular algorithm how to combine those objects and calculate conjoint effects from their realization.

Chapter 2. Theoretical study of socio-economic effects assessment

2.1. Literature overview

2.1.1. Literature review in terms of assessed socio-economic effects

Public infrastructure projects have several specific characteristics, which are to be taken into account while deciding whether to implement or not that particular project. Among those characteristics are high capital intensity, long payback periods, low values of NPV, low values of NPV, strong incentives of public authorities to implement the project. Thus, usual methods of financial investment project assessment are not applicable for public infrastructure projects. Socio-economic effects are proven to be several times higher than monetary incomes of project operation (Финансирование создания…, 2002). Efficiency can be economy-wide, ecological, budget, financial, social and technical. Each type of efficiency is defined by cost-benefit effectiveness. Social efficiency reflects social outcomes of investment processes and can be defined as increase in wealth of population, demography tendencies (Sabirov, 2011).

Commercial assessment can show very low results and sometimes NPV can be negative, however the socio-economic outcomes can be very high, thus these characteristics must be evaluated when considering public projects (Alaev, 2015). The overall benefits of a transport infrastructure project are the sum of all possible benefits for the particular project. The more benefits are included to the sum the higher overall impact of the project is (Lehovec, 2004).

Socio-economic assessment implies complex analysis of economic and social consequences of the project implementation. The result of socio-economic investment projects is reaching a particular public utility. i.e. qualitative improvement in healthcare, culture, education in a country or a region (Sabirov, 2011). Socio-economic effects are those indirect long-term effects that occur in other markets apart from transport system. Accessibility and other effect created by transport network influence other markets and thus create long-term change in agents' behavior and state. These indirect effects are separated into two different blocks: economic and social (Klementschitz, 2003).

The economic effects of transport infrastructure development can be direct (economic costs and benefits like travel-cost savings. For the direct benefits time economies, energy (fuel) economies, reduced vehicle wear and reduced accident rate are included (Lehovec, 2004)) and indirect, in other research papers they are associated as wider economic effects, like productivity gains of firms and distributional effects (Karst & Wee, 2004). Road capacity improvements lead to less transport costs. Such effects as fuel consumption, wear and tear and transit time of traffic, accidents are now widely used in project assessment (Elvik, 2010). Indirect effects also include in general the following impacts:

- a greater amount of job opportunities;
- improved environmental conditions (noise, emissions) for the population along existing congested roads;
- evaluation of the ecological effects on a territory;
- growth in the value of a territory due to the creation of commercial and industrial zones;
- increased economic power of municipalities due to better accessibility to transport;
- improved territorial access for the tourist trade and the population's leisure time;

- revival of building activity during the construction of the transport route and its subsequent maintenance;
- setting limits for sustainable territorial development. (Lehovec, 2004)

Social effect implies a complex of social results of project implementation, projected on quality of social environment having both positive and negative values (Sabirov, 2011). Social effect can be direct and indirect. Direct effect appears due to construction and future exploitation of the transport project, indirect effect considers taxation, additional investments, development of production, region. Peculiarity of indirect effects is shown to be constant increase, for instance, creating new job places decreases unemployment rate in region, which leads to increase in people's incomes and consequently to increase in purchasing power. The cycle restarts with creation of new job places and so on. However, negative social effects can appear because of projects implementation, like increasing migration, heavier traffic, social conflicts, ecological factors (Danchenko, 2016).

The research (Alaev, 2015) assessed socio-economic efficiency of infrastructural projects in road construction and preschool education. The basic social effects were depicted. For roads those are:

1. Decrease in travel time for individual vehicles and public transport
2. Decrease in prime cost of transported cargo
3. Decrease in number of traffic accidents
4. Increase in service supply

However, it was proved that "creation of job places" is less significant than those effects listed above, due to temporary increase in job places because of road works. In addition, this research states that there are more economic effects than social one for road construction.

The problem of Russian Federation poses necessity in one unified system of projects assessment including not only economic effects but also social one and multiplier effect. The research provides information for future work as to develop a document that contains model of transport project assessment in terms of social effects and multiplier effects (Koncheva, 2015).

All papers state the necessity of socio-economic effectiveness assessment and pose reflect which of them are assessed in Russian Federation. However, none of the research papers explain a broader concept of travel time savings and how people evaluate their time.

2.1.2. Literature review in terms of Value of travel time savings

The value of travel time savings (VTTS) is the monetary value that consider reduction of travel time of passengers. European countries also consider this effect as "the time needed to undertake personal travel from origin to destination including in-vehicle time and interchange"

(EUNET). Some countries, like Germany take into account only in- vehicle time, excluding interchange from calculations. The travel time as it is an intermediate good. Thus, the final product is exactly saved time after implementing of transport project. There is no universal value of time, in each country it is assessed differently, but what is equal in all of them is that people are ready to pay more to decrease travel time to some extent and under particular circumstances. VTTS goes close to willingness-to-pay and it is reflected in a number of research. Some researches even suggest assessing WTP instead of VTTS as it is claimed to be a stronger indicator of the necessity of the project implementation (Mackie et al., 2001).

What stands behind any model of estimation of VTTS is that it is presented as a trade-off between money and time and is calculated as the ratio of time on price coefficient. However, in practice wider variations of VTTS estimations are introduced and used. These variations are connected to the trip characteristics, i.e. trip distance, trip purpose, trip costs, etc., the type of user or his/her socio-economic status, i.e. gender, level of income, family status, etc. or attributes of the transport mode, i.e. comfort, safety, fare, etc.

Ramejerdi (1993) explains some of these variations. For instance, trip purpose might have variations between commuting and non-work trips because people value this time differently, in some cases commuting is valued higher than non-work trips. The model of estimation may be linear in the simplest case and non-linear according to time components of the trip.

A number of studies have been dedicated to VTTS, especially in the Western countries. Value of Time (VoT) studies have taken place for instance in Norway (Ramjerdi et al., 1997), Sweden (Algers et al., 1998), Denmark (Fosgerau et al., 2007) and Switzerland (König et al., 2003). The latter provides a brief review of the available work in the field. Fosgerau et al. (2007) focuses on the cross mode variations in VTTS.

A cornerstone of social analysis is the Kaldor-Hicks criterion – if the winners can compensate the losers, then the project is considered to improve welfare. In this case, no differentiation should take place in VTTS assessment. However, as there are factors that influence value of time perception for each individual person, creating groups of users, there appears a contradicting point of view. This is supported by researchers that state that the VTTS increases with income (Abrantes & Wardman, 2011; Amador, González, & Ortúzar, 2005; Hess, Bierlaire, & Polak, 2005; Wardman, 2001; Axhausen et al., 2008).

Two contradicting points of view create a large dispute. Some authors and applied appraisal guidelines support using actual VTTS and hence differentiating the VTTS among user groups (Sugden (1999), Harberger (1978)). Other authors and appraisal guidelines take the opposite extreme, arguing that a single or very few VTTS:s (often called equity values) should be used for all private journeys (Pearce and Nash (1981); the current German and British appraisal guidelines). The Netherlands used to apply equity values of time but the new official VTTS:s (Kouwenhoven et al., 2014) are differentiated by mode in the appraisal guidelines.

Metz (2008) introduced an idea that value of travel time savings is not practically useful. The central idea is that people have 'time budget', which they are ready to spend on travelling. It varies from country to country, but in general it is around 1 hour. Thus if any transport project implementation gives people 10 minute travel time saving, they are eager to prolong their trips so that it still takes 1 hour. As a result, people do not economy their time, instead, they travel more. That is why Metz offers to introduce value of access instead of value of travel time saving. Value of access mean that more people get opportunities to find a better job, get better services and this will impact overall wealth of the area.

All papers showed that income is a valuable feature that highly influences VTTS, however there are no recommendations on inclusion of this factor into the models, only as grouping of people. In the end, this does not give a valuable results. Another question, which arises and is answered differently, is whether to differentiate VTTS based on trip characteristics or its attributes. Should time of the day be taken into account, especially as peak hours arise mostly when people go to or from work and this time is perceived as more expensive then free time? Should geographical feautres be taken into account?

2.1.3. Literature review in terms of approaches to assessment

Travel time savings are assessed all over the world. Any transportation project requires such assessment. European countries, the United States of America, countries of Oceania assess VTTS. However, there is no universal approach to calcualtions of VTTS. Each country has its' own methodology and reasons for that particular algorithm. Foreign research is organized in table 5.

Table 5

Literature review on foreign VTTS methodologies

D. Metz (2008)	In the long - run average travel time is conserved, which implies that users benefit from improved transport infrastructure and thus get additional access to further distances. Introduces value of access rather than value of time savings.

The US Department for transport (2005) Graham (2005) Eddington (2006)	Value of access attracts attention as it can show productivity benefits of agglomeration. Among those benefits there are better matching of people to jobs, better connection of suppliers and markets; information spillovers between firms
The US Department of transport (2005)	Introduces the following determinants of VTTS: ✓ **trip purpose** (business travel, personal and leisure travel). The research states that VTTS for personal travel is lower than the hourly earning rate. Also those who earn salary have little opportunities to convert extra time into added income. In case when travelling gives satisfaction to users, VTTS can be negative, if individual is actually willing to spend extra time on travelling. If work can be done *en route* by means of laptop, smartphone, documents on paper, discussions, time savings can increase productivity slightly, if all, implying a lower VTTS. ✓ **Personal characteristics** (age, sex, education, employment are included as explanatory variables in social and economic research) ✓ **Hourly income** (median is offered to be included instead of mean wage, as it is the most reliable) ✓ **Mode and distance** (mode choice including comfort, privacy, prestige, travel time and travel cost) ✓ **Comfort** (actions that shorten the time period during which users experience uncomfortable conditions, and those that improve conditions throughout the whole trip)
Mackie et al (2001)	VTTS is estimated to be lower for personal than for business travel .
Shao, Liu et al (2014)	VTTS is estimated through willingness to accept (WTA) for the private car owners. It shows that trip purpose, trip length, time savings, cost savings, income, allowance from employee impact WTA. The research revealed that time savings and cost savings are main influence variables. Commuting is influenced by trip length, trip cost, cost savings, time savings and income. The research however does not take into account individual preference in driving and comfort level.

BCHF et al (2002)	The research used SP survey of car drivers and reveald a best fit function to data, which expressed unit VTTS as varying inverse proportion to a linear function of trip distance. Elasticity of 0.05 to 0.13 for trips longer than 5 km and shorter than 100 km was estimated.
Wardman et al (2008)	The study showed that VTTS increases with respect to trip distance or trip length. Income differences little affect elasticity values, which were in range 0.06 to 0.41.
Fosgerau et al (2007)	Study included model with separate time values for "short" and "long" trips with 25 km – median line as the threshold. The research found that mean VTT for car drivers in free-flow conditions was 20% lower for the long trips than for the short trips. Mean VTTS for each mode raised as the level of time savings raised , and threshold after which the increase diminished was 15 minutes for all modes of transportation. For small time savings such as 3-5 minutes, unit values were twice less than for the threshold values.
Borjesson and Eliasson (2012)	Found that for time savings of 5 minutes, unit values were approximately 70% of the threshold value for car trips, and 50% of the threshold for public transport trips. The threshold meanwhile was calculated as 45 minutes for car trips, and 25 minutes for longer distance public transport trips.

It can be seen that various papers state that it is important to differentiate value of travel time savings for different layers of people and by various parameters. Key parameters, influencing the overall savings, differ from a country to country. However, most papers state that trip purpose is a key feature that impacts how people evaluate their time. Commuting is claimed to be evaluated lower than leisure trips. Trip distance is also crucial, as for short trips people also tend to believe their time is more expensive.

Even though for these countries this list of parameters is valuable, it is important to understand what features are crucial in Russian reality, for Russian people.

2.1.3. Literature review in terms of methodologies

There are still issues with social effects that must be included in the analysis, as not all effects can be revealed for the project. Not all of effects can be calculated, especially qualitative. Adding them subjectively can mislead the assessment. Moreover, qualitative estimates cannot be used in financial models (Alaev, 2015).

Deluka-Tibljaš et al.; Šelih et al.; Stevens; Gühnemann et al.; Mackie et al., Hyard, Jones et al. claim CBA methodology in complex with multi-criteria analysis to be the most appropriate for socio-economic efficiency analysis.

The survey (Mackie, 2014) is based on a number of countries, where CBA plays a formalized role in decision making. These countries are England, Germany, the Netherlands, Sweden, the USA, Australia, New Zealand. One of the conclusions of the research is that methodologies, valuations and areas of application are broadly similar across the studied countries. It is shown that CBA is not the only way to assess socio-economic efficiency of infrastructure projects. As well as CBA various types of non-monetized benefits are included in the assessment framework.

Value of travel time savings by trip purpose, mode, trip length as well as safety values are used in countries analyzed in the research. Most countries include road travel time variability and the value of the standard deviation relative to the value of travel time. In this case delays are measured for scheduled traffic or long unexpected delays in road traffic. It is noted that countries are challenged to model the impact of projects in terms of travel time variability. Crowding relief is also measured distinguishing travelling seated or standing, mark-ups on in-vehicle time for driving in congested conditions. Introduction of walking and cycling schemes allows the countries to introduce fitness and health benefits. Physical activity and life expectancy are used for evaluations in England and Sweden (Mackie, 2014).

The research depicts the most disparate question of wider economic impacts. Different countries use various methodologies to capture those impacts like tax wedges and agglomeration effects or inter-industry linkages with focus on freight transport. Regional or local macroeconomic models are used for applied approaches that go beyond the economic welfare framework of CBA (Mackie, 2014).

Cost-benefit analysis is a traditional approach for European countries and Russian projects assessment. This method is widely spread as it allows calculating monetary benefits over costs. However, this method does not imply assessing multiplier effect on complex territory development and theoretical basis of this approach is that there is ideal competition, which obviously not true. Wider economic effects started to be taken into account and the research shows how UK, Germany, Sweden and USA broaden cost-benefit analysis (Koncheva, 2015).

Cost-benefit analysis and similar approaches capture costs avoided like travel time saving, vehicle operating cost savings and reduction in accident costs. However, there are more than these benefits and figure 3 illustrates the combination of effects. It shows that welfare and

GDP have an overlap and all of those effects are not covered by cost-benefit analysis (Department for transport, 2005).

The research (Korytarova, 2015) analyses 27 Czech large-scale transport infrastructure projects implemented during 2013-2015 using CBA methodology. The research focuses on examining benefits, like savings in travel, operating costs and savings in travel time costs, reduction in accident costs and savings in exogenous costs, as well as total agency costs. These parameters are introduced as main inputs into calculation of socio-economic efficiency ratio of the project - NPV, IRR, BCR.

Regression analysis and correlation coefficient of benefits and total agency costs have been used as method of research. Results of the research prove savings in travel time costs to have the greatest share in regression model and the highest correlation coefficient in relation to total agency costs. It is concluded that massive transport infrastructure projects still have positive contribution in socio-economic development (Korytarova. 2015).

The research examines possibility to turn 'hard to quantify' effects of transportation infrastructure projects into monetary values. Environmental quality, health and wider economic effects are discussed in the research. The tendency of usage of such effects is proved to be strengthening and developing. Concrete projects were evaluated in Australia, Wisconsin and Appalachian economic development programs (Weisbrod, 2009).

Cost-Benefit analysis is the most spread approach to assess project effectiveness. The major drawback of this approach is that in order to conduct this type of analysis many social effects must be omitted as they cannot be turned into monetary form. Those that can be converted, might be calculated differently and get different results exactly in that part of formulas, where this conversation is performed. The WCEA approach is more tolerable with social effects. However, it is subjective and can be interpreted in different ways. This makes thus approach not as popular on global market. Russian projects are assessed by CBA.

2.2.1. Foreign methodologies of VTTS assessment

All countries use monetary values for travel time savings (VTTS). In Germany and New Zealand, however, differentiation by transport mode is used. In other countries appraisal guidelines the following characteristics are revealed:

- In England differentiation by trip purpose is introduced, i.e. commuting travel time savings are 10% higher than non-work travel time as well as leisure trips. The same principle is used in Netherlands and Sweden, although percentage of difference is larger;

- In Germany there is difference in trip length. For travel time savings less than 5 minutes 30% discount is applied to VTTS; Sweden also differentiates VTTS by trip length, whereas in England there is no such differentiation;
- Walk and wait multiples to in-vehicle time are widely used, for instance in England, Australia and USA with various multiples;
- The England employers business values appear high both absolutely and relative to the non- work values (over 5 x the non-work value versus 3-4 x in the other countries (Mackie, Worsley, 2013).

Not all national appraisal guidelines include a definition of passenger travel time savings. The majority of countries differentiate between the values that are used for working trips and nonworking trips. The majority of countries that have guideline values for work trips use the costs saving approach as the valuation methodology. Two countries, Sweden and the Netherlands use the Hensher approach (Hensher, 1977). Austria, Lithuania, Italy and Portugal use some relationship to GDP/capita whilst Switzerland uses a relationship to non-working time. A variety of methods are also used to value non-work VTTS. For the seventeen countries that have guideline values for non-work VTTS, six base their valuations on willingness to pay surveys, whilst seven use some form of fixed relationship with the wage rate or the value of work VTTS. The remaining four countries use methods based on the international comparisons, literature surveys and analysis of macro economic data such as national income. Those countries that do not differentiate between work and non work VTTS either use an average value (Belgium, Slovak Republic, Czech Republic, Spain, Hungary,) or do not have any guideline values (Luxembourg, Poland, Estonia, Cyprus, Italy, Portugal) (Odgaard, 2006).

Trip purpose is only one of the categories of VTTS that differ by country across the EU. The next two most common differentiations are mode of transport (16 countries) and multiple non work categories (9 countries). Two countries differentiate by income group (Netherlands and Switzerland) and both the Netherlands and the UK use different values for drivers and passengers. The other methods for differentiating values include urban/interurban differences (France), length of Journey (France, Switzerland and Sweden), delays (Denmark and Sweden) and different days of the week (Hungary) The principal reasons for the variation in VTTS values within a country are disaggregated by income, distance and mode (Odgaard, 2006).

Table 6

Approaches to estimating values of travel time (HEATCO, 2005)

Values	Method	No. of countries	Countries
Work Values	Cost Saving	10	*North/West*: Denmark, Finland, France, Germany, Ireland, UK *East*: Latvia, Slovenia. *South*: Greece, Malta
	Hensher	1	*North/West*: Sweden
	WTP	1	*North/West*: Netherlands
	Other	5	*North./West*: Austria, Switzerland. *East*: Lithuania *South*: Italy*, Portugal*
Non-work	% of Wage Rate	6	*North/West*: Denmark, Finland, Ireland *East*: Latvia, Slovenia. *South*: Portugal*
	WTP	6	*North/West*: Germany, Netherlands, Sweden, Switzerland, UK *South*: Greece,
	International comparisons	1	*South*: Malta
	Other	4	*North/West*: Austria, France *East*: Lithuania,. *South*: Italy*
Average	Wage Rate Studies	2	*North/West*: Belgium (Wallonia region) *East*: Slovak Republic
	WTP	2	*East*: Czech Republic *South*: Spain.
	Other	3	*East*: Hungary, Estonia* *South*: Italy*
No Guidelines		6	*North/West*: Luxembourg *East*: Poland, Estonia *South*: Cyprus, Italy, Portugal.

Most countries except USA have multipliers to in-vehicle time for crowding relief on public transport, and English practice has developed strongly in relation to rail commuting and long distance travel. Unlike England, Sweden and New Zealand have mark ups on in-vehicle time for driving in congested conditions. Comfort and crowding have seen a significant amount of research work in recent years; it is probably true to say that the focus of policy attention is shifting from travel time savings to journey reliability and quality and that the effort to improve the appraisal system is responding to this development (Mackie, Worsley, 2013).

There is some variation in the treatment of growth in real VTTS over time. With respect to passenger time savings 8 countries have no guidelines, 6 assume there will be no change and the remaining 12 use some form of real growth mechanism (Odgaard, 2006).

2.2.2. Russian methodology of VTTS assessment

Russian methodology of VTTS assessment contains three steps:

1. Calculation of public losses, connected to travel time expenses of population on road areas under basic conditions (without project implementation)
2. Calculation of public losses, connected to travel time expenses of population on road areas under project conditions (after project is implemented)
3. Calculation of difference of first two parts

As a result there might appear negative number (which means that project implementation will even worsen the currently existing situation), no difference ($\Delta P_t = 0$, which means that project implementation will not change the situation), positive difference (which means that population will decrease travel time and therefore public losses will decrease)

In terms of formula the effect of travel time savings is determined by the formula:

$$\Delta P_t = \sum_{i=1}^{n} (P_{it}^{b} - P_{it}^{pr}),$$

where P_{it}^{b} and P_{it}^{pr} are public losses, connected to travel time expenses of population on road area i corresponding to base and project conditions.

Yearly losses, connected to travel time expenses of population on each area, are calculated by the formula:

$$P_t = 365 * C_t^{pas}[N_t^{car} B^{car}\left(\frac{L}{V_t^{car}} + t_t^3\right) + N_t^{bus} B^{bus}\left(\frac{L}{V_t^{bus}} + t_t^3\right)]$$

where C_t^{pas} is average value of losses of national economy per 1 person/hour being on travel

N_t^{car}, N_t^{bus} - average annual day's traffic correspondingly to private cars and buses on road area, vehicle/24 hours;

B^{car}, B^{bus} - average amount of passengers in one vehicle (car or bus);

V_t^{car}, V_t^{bus} - speed of vehicle (car or bus) on road area, km/hour;

L – length of the road area;

t_t^3 – extra time spent by one vehicle in areas of clogged traffic (at traffic lights, barriers, in "traffic jams", on ferry crossings, etc.)

Intensiveness forecast of traffic N_t per each ongoing year can be defined by:

$$N_t = N_0 * K_t,$$

where N_0 – average day traffic intensiveness in base year; $K_t = (1+p)^t, p = 0.01/0.12$ – intensiveness rate of increase.

Average speed of traffic on each road interval is defined by:

$$V = \sum_{i=1}^{n} V_i * \alpha_i,$$

where $V_i = V_{max} - t\sigma_V - \Delta V$ – average speed on i-interval, α_i – length proportion of i-interval with the same conditions for traffic to the whole road, V_{max} -- the actual maximum possible speed of a single vehicle, σ_V -- standard deviation of free-flow traffic, ΔV – parameter, that considers impact of intensiveness on vehicle flow speed.

In other words, the formula calculates public losses on a particular road object under base conditions and project conditions. Road object, which is planned to be reconstructed or newly built, is divided into several intervals and for each of them the parameters are calculated, summed up. Then public losses under base conditions are subtracted from the project conditions.

The project is beneficial if losses are minimal and thus savings are maximum. This can help to compare several alternatives and choose the best option.

There are several key features of this formula. This formula does not differentiate people who are inside cars and buses. For instance, in each bus there is at least one driver (in Russia, there are also conductors. These people do not waste their time in traffic, because it is their job. The same can be implied about taxi drivers. Their value of travel time is neglected.

2.2.3. Comparative analysis of existing methodology with the foreign cases

All researched methodologies do take value of travel time savings into consideration and various resources state that major impact of new transport infrastructure project is VTTS. This does not contradict to the major idea of socio-economic effects of any transport system improvement. VTTS can be considered both economic and social effect, as it provides stimulus for faster and more effective logistics and for people to increase their life satisfaction if they do not spend extra time on commuting.

Some countries differentiate VTTS by income groups as it is the main driver of almost any market system. Other European countries including the United States of America differentiate VTTS by trip purpose, particularly including work-trips, non-work trips, and some define as distinct group business-trips. In addition, a number of European countries base calculations on willingness to pay surveys, whilst seven countries use some form of fixed relationship with the wage rate or the value of work VTTS.

Trip purpose is only one of the categories of VTTS that differ by country across the EU. The next two most common differentiations are mode of transport (16 countries) and multiple non work categories (9 countries). Two countries differentiate by income group (Netherlands and Switzerland) and both the Netherlands and the UK use different values for drivers and passengers. The other methods for differentiating values include urban/interurban differences (France), length of Journey (France, Switzerland and Sweden), delays (Denmark and Sweden) and different days of the week (Hungary) The principal reasons for the variation in VTTS values within a country are disaggregated by income, distance and mode (Odgaard, 2006).

Russian methodology of VTTS assessment does not provide any differentiation by any parameter. This is the main difference to the foreign practice. Russian formula of VTTS calculation basically calculates total amount of people/hour on the road area and multiply it by monetary coefficient, which can either include GDP or GRP, or in some cases average income and divide it by 365 days and 24 hours. Then this money is multiplied by 365 days and annual travel time costs are got.

In public-private partnership projects, willingness-to-pay surveys are conducted and income groups play major part in identification of whether people are ready for the project or not and whether they are ready to pay extra money for higher speeds and consequently less travel time costs. This procedure is not conducted for projects that are financed by state or regional budget, because these roads or other transport projects are not going to be organized with toll-system.

Interest of particular countries in terms of value of travel time savings concentrates on small time savings, i.e. less than 10 minutes. Some countries take into account differentiating trip length, as it can be assumed that people do not take into account 5 minute savings. Various research was held in this sphere. Consequently, some countries do include small time savings into their methodologies.

It can be concluded, that foreign practice does take into account various trip characteristics, passengers' socio-economic status or attributes of trips, making calculations of travel time savings more precise, whereas in Russian Federation these additional parameters are omitted. It does not only concern value of travel time savings which has the biggest impact of socio-economic efficiency on transport infrastructure projects, it also concerns other effects that can have additional parameters to make estimations more precise.

2.3. Summary of chapter 2

Public infrastructure projects have several specific characteristics, which are to be taken into account while deciding whether to implement or not that particular project. Among those characteristics are high capital intensity, long payback periods, low values of NPV, low values of NPV, strong incentives of public authorities to implement the project. Thus, usual methods of financial investment project assessment are not applicable for public infrastructure projects. Socio-economic effects are proven to be several times higher than monetary incomes of project operation (Финансирование создания…, 2002). Efficiency can be economy-wide, ecological, budget, financial, social and technical. Each type of efficiency is defined by cost-benefit effectiveness. Social efficiency reflects social outcomes of investment processes and can be defined as increase in wealth of population, demography tendencies (Sabirov, 2011).

Socio-economic assessment implies complex analysis of economic and social consequences of the project implementation. The result of socio-economic investment projects is reaching a particular public utility. i.e. qualitative improvement in healthcare, culture, education in a country or a region (Sabirov, 2011). Socio-economic effects are those indirect long-term effects that occur in other markets apart from transport system. Accessibility and other effect created by transport network influence other markets and thus create long-term change in agents' behavior and state.

The value of travel time savings (VTTS) is the monetary value that consider reduction of travel time of passengers. What stands behind any model of estimation of VTTS is that it is presented as a trade-off between money and time and is calculated as the ratio of time on price coefficient. However, in practice wider variations of VTTS estimations are introduced and used. These variations are connected to the trip characteristics, i.e. trip distance, trip purpose, trip costs, etc., the type of user or his/her socio-economic status, i.e. gender, level of income, family status, etc. or attributes of the transport mode, i.e. comfort, safety, fare, etc (Mackie, 2014).

It can be seen that various papers state that it is important to differentiate value of travel time savings for different layers of people and by various parameters. Key parameters, influencing the overall savings, differ from a country to country. However, most papers state that trip purpose is a key feature that impacts how people evaluate their time. Commuting is claimed to be evaluated lower than leisure trips. Trip distance is also crucial, as for short trips people also tend to believe their time is more expensive.

Trip purpose is only one of the categories of VTTS that differ by country across the EU. The next two most common differentiations are mode of transport (16 countries) and multiple non work categories (9 countries). Two countries differentiate by income group (Netherlands and Switzerland) and both the Netherlands and the UK use different values for drivers and passengers. The other methods for differentiating values include urban/interurban differences (France), length of Journey (France, Switzerland and Sweden), delays (Denmark and Sweden) and different days of the week (Hungary) The principal reasons for the variation in VTTS values within a country are disaggregated by income, distance and mode (Odgaard, 2006).

Russian methodology of VTTS assessment calculates public losses on a particular road object under base conditions and project conditions. The project is beneficial if losses are minimal and thus savings are maximum.

There are several key features of this formula. The formula does not differentiate people who are inside cars and buses. For instance, in each bus there is at least one driver (in Russia, there are also conductors. These people do not waste their time in traffic, because it is their job. The same can be implied about taxi drivers. Their value of travel time is neglected. Furthermore, it does not include any of the parameters used by foreign countries. Foreign practice does take into account various trip characteristics, passengers' socio-economic status or attributes of trips, making calculations of travel time savings more precise, whereas in Russian Federation these additional parameters are omitted. It does not only concern value of travel time savings which has the biggest impact of socio-economic efficiency on transport infrastructure projects, it also concerns other effects that can have additional parameters to make estimations more precise.

Chapter 3. Empirical study of VTTS methodology

3.1. Case-study description

Any transport infrastructure projects requires previous effectiveness assessment. Methodologies to calculate costs and benefits of project implementation are universal in all regions of Russian Federation. That's why Saint-Petersburg agglomeration was chosen as a case-study territory to evaluate quality of VTTS calculation methodology and extract knowledge out of existing transport infrastructure.

Previously it was discussed that Saint-Petersburg has high level of congestion, particularly around 40 extra minutes are spent daily by citizens on transportation. Yandex conducted research on congestion level in the city. It showed that central parts of city have traffic jams, but most of them are allocated in bordering districts with Leningrad region. These territories are so called dormitory districts where people mostly spend their nights and create migration flows while commuting. Monocentric structure of road system in Saint-Petersburg influences these migration flows. Most of job places are concentrated within the city center or neighboring districts.

There are almost no territories for real estate within Saint-Petersburg. Those opportunities for building houses require high prices. This causes that people purchase apartments in newly created districts on the territory of Leningrad region or at the borders of Saint-Petersburg. Among those districts are Parnas, Shushary, Komendatsky prospect, Murino, Novoe Devyatkino, Peterhof highway, Krasnosylsky district and Kudrovo. These areas are packed with high-rise buildings and high density of population. Whereas transport infrastructure is not adapted to existing conditions which creates dense traffic flows and high congestion within these areas.

Consequently problems that arises for local authorities is what measures to take first in order to easen transport situation within these growing districts and what transport projects to implement so that they have the biggest effect on travel time saving for society. It is also essential to understand that each territory has specific features, particular structure of inhabitants with their own preferences and needs and it is important to consider them when preparing transport project. It considers not only physical infrastructure, like roads, railways, underground, but also opportunities for public transport.

When a set of measures is derived, as with strategy of transportation system development, it is important to research complex processes and migration flows that occur on the territory. But when it gets to local transport projects within one district it is important to hold profound research on this particular territory and adapt projects to perspectives of area’s development. What is usual about our transportation development is reacting to those conditions that currently occur. Most of the projects do not foresee ongoing future changes to territories. Thus, when transport project is implemented in most cases it does not change the situation radically. Several years later congestion reaches previous levels.

With all these premises, the idea of empirical part of the research is to concentrate on one specific area and evaluate how VTTS estimation could be improved for projects specifically for this area. For this Kudrovo village was chosen. There are several reasons to that. First of all, this territory grows rapidly. Real estate construction started only in 2006 and by now more than 1 million m2 of dwelling is commissioned. High-rise buildings can place more than 100,000 inhabitants. Currently official statistics states that 15000 people are registered on this territory. However, the actual number of people living in Kudrovo is much higher. People prefer to stay registered in Saint-Petersburg as they are able to get social services there, whereas in Kudrovo it is impossible due to absence of social infrastructure. As well as transport infrastructure.

Currently there are three two-lane roads that connect this district to Saint-Petersburg. Quality of road surfaces are below standards, but any road repair causes even worse traffic congestion.

However, there are opportunities for infrastructure development. In the middle of 20 century authorities planned to construct underground to this place. There is a tunnel that connects Kudrovo to underground station Dybenko. Unfortunately in the second half of the 20 century this project was frozen. What is to do now is to actually build the station and organize train flows.

Another opportunity is railway that goes along border of Kudrovo and Saint-Petersburg. It was previously used to connect the main railway from Ladozhsky railway station with factory zone. Now it is not used. To organize train connection it is essential to adapt intersection of this railway to the main railway highway. It requires, however, profound investments and will influence traffic of passenger and cargo transportation.

Tram railways are also possible to be constructed. Kudrovo village is 300 meters from Nevsky district of Saint-Petersburg with well-developed tram system. But its continuation on territory of Kudrovo requires constructing of a viaduct organizing tram routes across the district so that it operates in the most efficient way. Currently there are two projects of tram navigation within Kudrovo. One lies through the centre of the district, another goes along bordering streets.

There is no consensus yet on which route to implement. This also requires investments to creating physical infrastructure for trams. Thus decision should be taken with considering all prerequisites and possible consequences to inhabitants.

As Kudrovo is situated between Saint-Petersburg and ring highway, it is possible to connect it with both Nevsky district and highway to allow transport flows disperse according to trip destinations. Another issue that is crucial to transport connectivity is that south part of Kudrovo is connected to north part of Kudrovo only with one road. Thus, there is also a project to continue Stroiteley prospect and connect both parts.

There are now 7 projects for possible implementation on this territory, correspondingly to existing infrastructure opportunities.

3.1.1. Data collection

The first step of the research implies analysing needs and preferences of Kudrovo's inhabitants. In order to do this survey was conducted online and offline. Offline survey was aimed at not only collecting data, but also getting broader vision of how people live in a village and what other needs they have and what is their general understanding of perspectives on this territory. Offline survey was also held in order to do pre-test of a questionnaire. The citizens not only answered the questions but also gave comments on questions structures and things that could be improved

Online interview was conducted in social network in one of groups for inhabitants "Kudrovo's activitsts". The questionnaire was articulated into three sections:

- Demographics, in which details such as age, education, income, family status, were asked
- Attitude to the current road infrastructure in Kudrovov as well approximate time to enter/leave the districts
- Questions to reveal preferences in transportation mode choices and conditions under which people can choose whether fast but costly trips or slow but comfortable or safe ones

A pretest was conducted to ensure that the questionnaire possessed acceptable validity and realibility. It was organized offline in Kudrovo. Pre-test sample contained 10 people. They were not only asked questions from the questionnaire, but also asked about understanding of formulations of questions and whether they required extra explanation on what each question implied. After pretesting the questionnaire was shortened and some questions were reformulated.

The third part of the questionnaire was based on the previously prepared table with various modes of transportation that require such physical infrastructure as road and special railways. For these transportation modes a set of parameters was created with grades on each type of transport. The resulting table 6 contains information on all the possible alternatives in Kudrovo village.

Table 7

Features of transportation modes

	automobile road				railway		subway railway
	private car	taxi	on-ground public transport	marshrutka	tram	train	subway
cost	high	high	low	low	low	Middle	low
comfort	high	high	low	midlde	low	Low	low
speed	low	low	low	low	middle	High	high
prestige	high	high	low	middle	low	low	low
eco	low	low	middle	middle	high	high	high
alternative activities	yes	yes	no	no	no	yes	no
safety	low	midlde	high	middle	high	high	high
accessibility	close	close	middle	middle	far	far	middle

The parameters to describe modes of transportation were:

- cost (high, middle, low)
- comfort (high, middle, low)
- speed (high, middle, low)
- prestige (high, middle, low)
- ecologically-friendly (high, middle, low)
- opportunity to do business or leisure activities during the trip (yes, no)
- safety (high, middle, low)
- accessibility of transportation mode from houses (close, middle, far)

3.1.2. Descriptive information on data

The overall sample is 352 observations. The data is structured in Excel file and was processed in RStudio. All verbal formulations were restructured in numerical form. Sample profile is listed in table 8. The sample states that only 37,9% of respondents do not own personal car, however, this can also mean, that with transport situation improvement these are potential car owners.

Most of the respondents are from 26 to 40 years old, which signifies that mostly young families live in Kudrovo, whereas among pensioners there is only 1,5%.

Table 8

Descriptive statistics of sample

Parameter	Percentage	Parameter	Percentage
Gender		**Education**	
Female	63,6%	Secondary vocational education	5,8%
Male	36,7%	Incomplete higher education	9%
Age		Higher education	76,9%
18-25	15,3%	PhD, second higher education	9%
26-40	70,5%	**Family status**	
41-65	12,7%	Living alone	18,8%
Elder than 65	1,5%	Living not alone	81,2%
Car ownership		**Having children**	
no	37,9%	no	53,5%
Yes	62,1%	yes	46,5%

3.2.1. Primer PCA analysis results

Current sample included 144 respondents, 94% of who live in Kudrovo constantly. 40% of sample are females. On average, age of respondents lies in interval of 26 to 40 years, which means that Kudrovo's inhabitants are young families. 84,7% of respondents have a car. Most of people spend from 10 minutes to 1 hour to enter or leave Kudrovo.

Results of Principal Component Analysis are indicated on figure 1.

Visual analysis of PCA results shows that there are 3 major groups of factors that are correlated:

a. Income & prestige & willingness to pay for time reduction for commuting and leisure & gender.

b. Amount of people living together, children, car ownership, age

c. Level of education, willingness to switch from car to public transport for time reduction, willingness to commute faster in less comfortable conditions, need for safety

d. Orthogonal to other factors are willingness to go 20 minutes on foot until nearest transport and living status in Kudrovo.

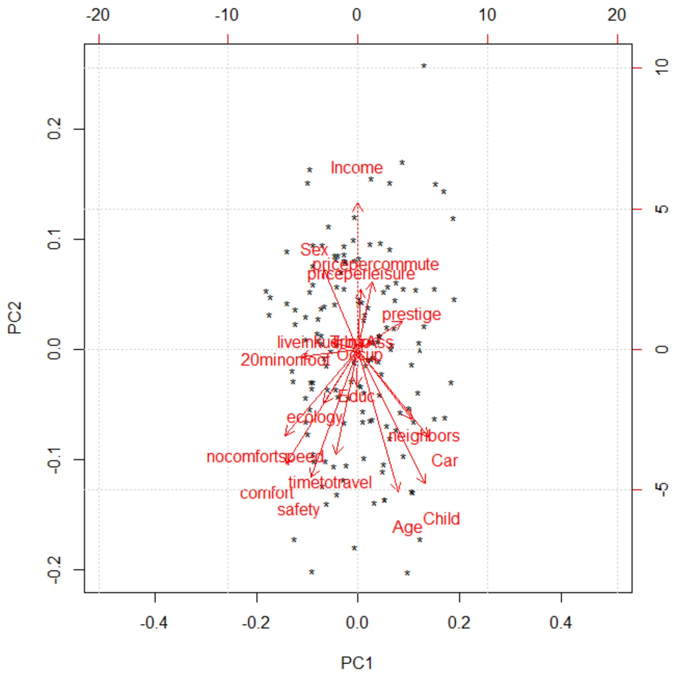


Figure 6 PCA results

Conclusions within those groups are the following:

1. The more people there are in a family the higher probability that there is also a private car
2. Age correlates with number of children, as the older the person is the mor likely he/she is to have children;
3. Income level influences willingness to pay more for less travel time;
4. Willingness to pay for commuting and leisure are highly correlated, thus there is no critical difference in citizen’s preferences depending on trip purpose;
5. Level of income is partially correlated to need of prestige;
6. People who spend more time on migration between Kudrovo and Saint-Petersburg are more likely to switch from personal cars to a less comfortable mode of transportation in order to decrease travel time. It is also correlated to willingness to commute in overcrowded underground for higher speed;
7. People with higher level of education are more likely to consider ecological issues of travelling and are ready to spend more time on commuting in order to create less ecological externalities;
8. It can be assumed that Y axis is willingness to pay for time reduction. Those factors that lie in positive interval are willingness to pay with money, whereas those that lie in negative interval reflect willingness to pay with feeling of comfort.

Principal Component analysis of the whole sample classified by the level of income of respondents showed that there are several groups of people that prefer a particular mode of transportation. Table9 presents that for all groups of respondents subway is appropriate.

Table 9

PCA results grouped by level of income

	Car	Bus	Speed tram	Tram	Train	Subway
Low income				+		+
Middle income	+		+		+	+
High income	+		+		+	+

However, there is still group of those who will use private cars even under current level of congestion as it is prestigious. Speed trams and trains are suitable for those groups of people that are ready to pay more for a faster commuting, whereas for low income group trams are suitable, because they also allow to travel faster, but cost much less than other types of transportation.

3.2.2. Cluster analysis results

Cluster analysis was held in order to reveal the most important factors that influence Kudrovo citizens' perception of time. In order to do it the whole sample was divided into two parts: people who are ready to switch cars to public transport and those who are not. The rest variables were chosen as independent ones.

As respondents' answers were structured in Likert scale of 5 degrees of agreement the sample was restructured, so that 1 and 2 (definitely not, not) would become 0 (not); whereas 4 and 5 (yes, definitely yes) would become 1 (yes). Intermediate answers of degree 3 were excluded from the sample due to no definite position of choice. As a result the sample got smaller, but still at 10% significance level.

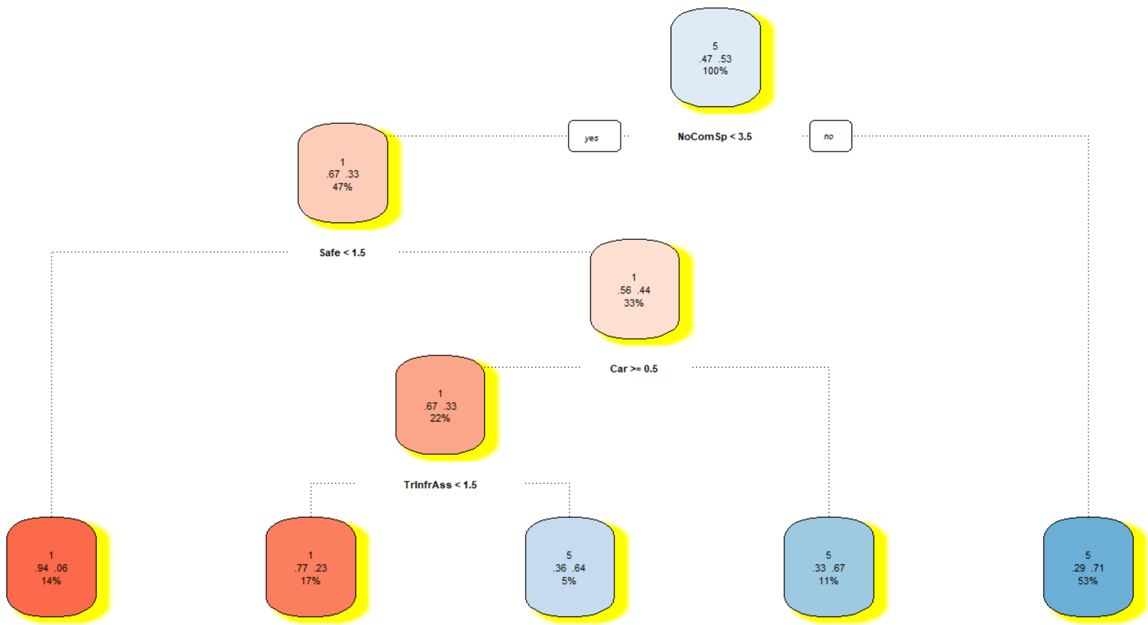


Figure 7 Cluster analysis results

The model was constructed in Rstudio and showed 76% goodness of fit. The most appropriate complexity parameter was 0.02. at this value model carried out 4 rules that identify people's readiness to switch from private cars to public transport. These are:

1. Readiness to commute in overcrowded subway twice faster than under base conditions
2. Readiness to travel 15 minutes more but in safe conditions
3. Ownership of car
4. How the person assesses the transport infrastructure

The main rule is readiness to commute by overcrowded subway but twice faster than under base conditions. As currently it is impossible to leave Kudrovo somehow else but by already existing roads, people have options to leave district: on foot (which takes around 30 minutes to the nearest subway station), by bus and commercial bus and by private vehicle. As a result for people that own private vehicle there is no sense in switching from car to bus, as it will take the same time, but with less comfort. If there is an alternative like subway station that is situated within district, people are ready to switch and sacrifice personal comfort but for higher speed and thus less travel time.

The second rule is safety. People value time less if they are provided higher level of safety. If private vehicle is considered as more dangerous mode of transportation, which does not allow to concentrate on reading, making phone calls, writing business letters, public transportation can allow these options under basic condition that it will be convenient for people. Thus still there is an option that mode of transportation must be comfortable and safe.

However, part of respondents is ready to suffer from discomfort, but to come faster to their point of destination and do the whole list of activities already there, instead of doing business *en route*.

The second model that was constructed within cluster analysis is with factor of choice being willing to pay twice per commuting but arriving twice faster. At the first step the model more than 5 rules of decision-making. Among them is willingness to pay twice more per leisure trip with 2 times faster arrival, income of respondents, safety, ownership of car and readiness to switch from private car to public transport. The initial decision tree is shown in figure …

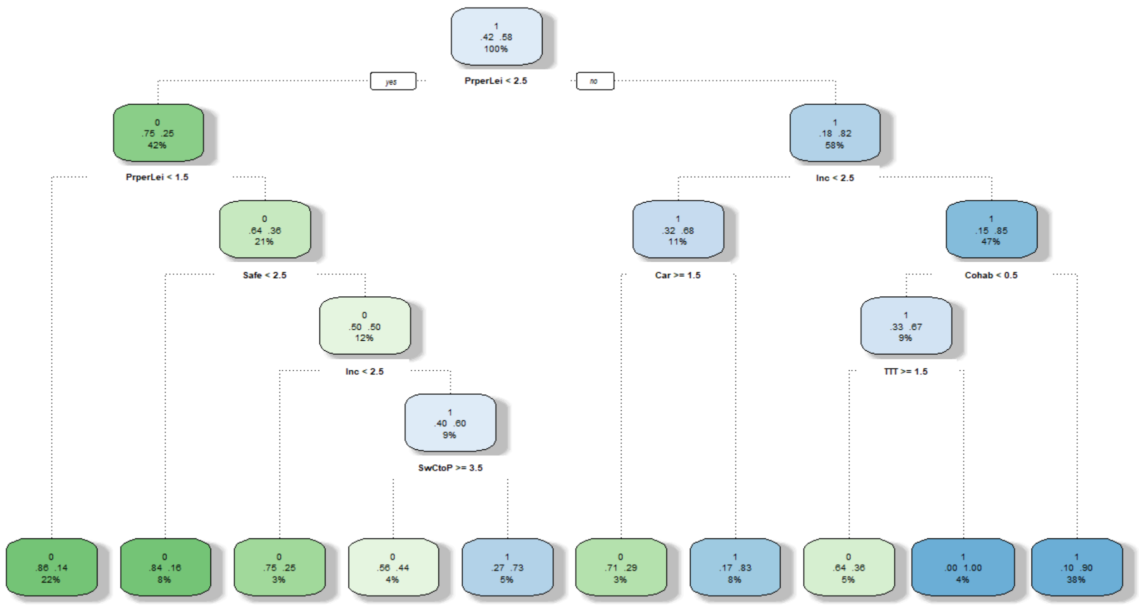


Figure 8 Cluster analysis results

However, after pruning the tree the program shows that there is only one significant rule, which is willingness to pay for leisure trip twice more but guarantying twice-faster arrival. This leads to the conclusion that respondents to not differential business-trips and leisure-trips. There are either ready to pay disregarding trip purpose, or they are not ready to pay extra at all. Consequently, within the sample that was collected for this research, there is no differentiation between trip purposes, thus foreign practice in setting different weights depending on trip purpose is not suitable, as it is not relevant to Russian reality.

Another technical comment is that prediction power of this model is 83%, which is even higher than previous model that had 4 rules. This fact supports the idea that people do not see difference in trip purpose and thus value their time similarly when travelling to work and for leisure activities.

Cluster analysis provides platform for further modification of the formula of VTTTS. Foreign practice cannot be implemented as it is not relevant to Russian reality (under assumption that sample is 10% significance level representative for Saint-Petersburg population). Level of comfort should be reflected in formula as it is an important factor for people's perception of time.

3.2.3. Formula testing

Currently existing formula of VTTS reflects total travel time on a particular road area in monetary form. The main principle of VTTS to be successful is that its project value is smaller than under basic conditions, which means that with implementation of road project people will spend less time passing this area. The total amount of time expenditures is calculated from average car and bus intensiveness, average amount of passengers in both modes of transportation, average travel time and delay time. This total amount of hours is multiplied by monetary coefficient. In order to reduce travel time expenditures, intensiveness should decrease, amount of people should decrease, average speed should increase and delay time should decrease as well.

The formula does not provide information on how people evaluate this time themselves. The information on how much time people spend on their travelling can remain the same, but what should be improved is how this time is reflected in monetary terms, as this will be taken into account when deciding on implementation of the project. From Principal component analysis and Cluster analysis comfort was extracted as an influential parameter. As there is no universal measure for comfort on the road, indirect parameter should be obtained for this purpose.

The parameter that will reflect comfort of passengers should be included as a multiplier satisfying several conditions:

1. It is in interval [0,1];
2. It is presented in both estimations for base and project conditions;
3. It enlarges travel time costs for worse conditions and decreases costs for better conditions;
4. It reflects degree of comfort of passengers;
5. It does not contradict mathematical and logical framework of the formula;
6. It can be estimated and what is better, it is already estimated;

In methodology of roads assessment, it was found that there are different classes of roads that have 3 basic parameters: load coefficient, motion saturation factor, motion speed factor.

Under various values of these factors road class is defined. The highest class is A and the lowest is F. each class also has such characteristics as characteristics of vehicle flow, flow state, emotional load of drivers, driving convenience, economic efficiency of the road. In order to increase class of the road, load coefficient should decrease, motion saturation factor should decrease and motion speed factor should increase.

All three parameters satisfy 1, 2, 4, 5 and 6 conditions stated for proposed coefficient. Motion speed factor does not completely satisfy the 3 condition. So, the choice lies between motion saturation factor and load coefficient.

Motion saturation factor is defined by formula:

$$\rho = q_z/q_{max},$$

Where q_z—average density of traffic, vehicle/km; q_{max} – max density of traffic, vehicle/km

Load coefficient is defined by formula:

$$z = N/P,$$

Where N – traffic intensiveness, vehicles/hour, P – practical carrying capacity of the road, vehicle/hour.

The second parameter analyzes practical carrying capacity of the road and compare it to the base conditions. Particularly it reflects loaded capacity of the road from 100%. The advantage of this coefficient is that it compares the current capacity with the ideal capacity of the road and the lower it is, the better traffic condition there is on the road. If congestion level decreases, passenger and driver comfort increases.

The proposed formula is determined by:

$$P_t = 365 * \frac{C_t^{pas}}{1 - z} * \left[N_t^{car} * B^{car}\left(\frac{L}{V_t^{car}} + t_t^3\right) + N_t^{bus} * B^{bus}\left(\frac{L}{V_t^{bus}} + t_t^3\right)\right]$$

Where z is a load factor which lies in interval [0,1].

Monte-Carlo simulation was held for 100 000 scenarios. The final distribution is right-skewed and is smooth, which proves the formula to be stable.

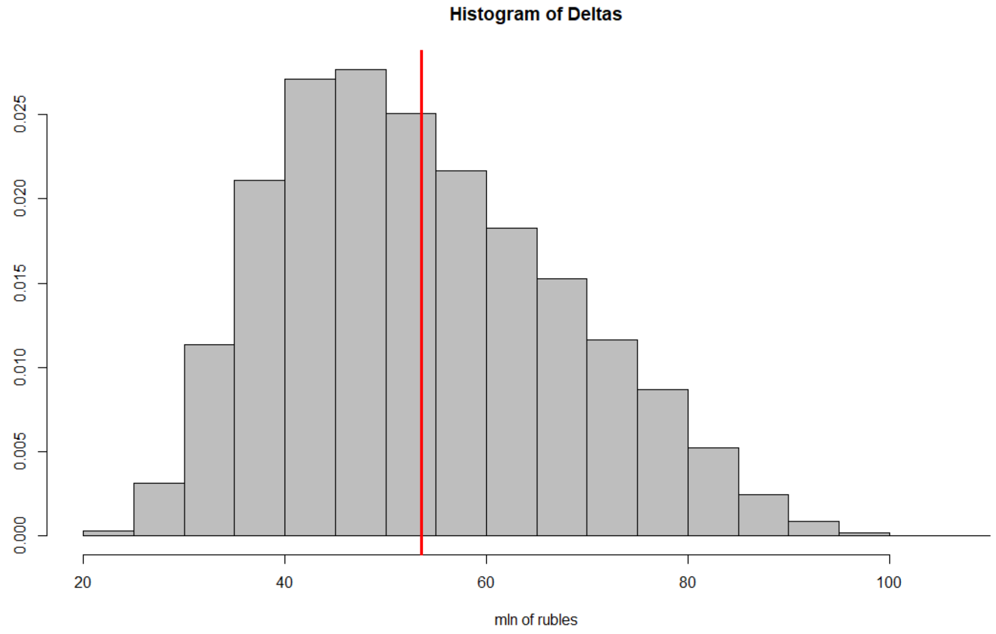


Figure 9 Distribution of deltas after Monte-Carlo simulation

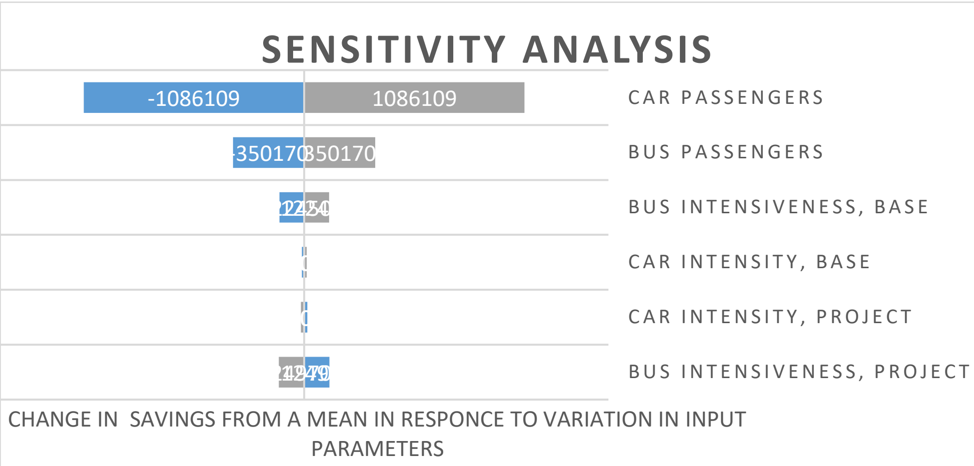


Figure 10 One-way sensitivity analysis

One-way sensitivity analysis showed that the major impact on value of VTTS have numbers of car and bus passengers. On average if a car has one additional passenger the change in VTTS will be more than 10 mln rubles, whereas one extra passenger in bus will bring extra 350 thousands of rubles. The negative impact on VTTS brings increase in intensiveness of buses.

3.3 Summary of chapter 3

The empirical study of Russian methodology of VTTS assessment contained several steps:

1. Comparison of currently existing methodology to foreign practice of VTTS assessment;
2. Collecting primary data on experimental area, which was chosen for research;

3. Econometric methods of data processing application, including descriptive analysis, principal component analysis, cluster analysis;

4. Modification of currently-existing formula by introduction of extra multiplier that will reflect the most significant features that influence people's perception of time;

5. Testing of formula with Monte-Carlo simulation in order to check its stability;

6. One-way sensitivity analysis with construction of tornado diagram in order to extrac the most influential parameters of the formula;

7. Providing policy implications for state authorities for improvement of VTTS assessment methodology;

The research showed that comfort is one of the major factors that influence people's behavior and mode choice. The largest amount respondents are ready to sacrifice their comfort in order to commute faster. It should be also taken into account that Kudrovo village undergoes challenge in transport infrastructure and it does not cover all the needs of inhabitants of this area. The results also showed that there is a group of respondents that are still ready to pay extra travel time for prestige and are not ready to switch modes of transportation in order to decrease travel time. This proves that people evaluate their time differently and that it depends on various factors.

Change in formula of VTTS assessment was a try to include an indirect coefficient of comfort, particularly load factor. As there is a direct connection between load factor of the road and people's feeling of comfort as well as economic efficiency of the road. Monte-Carlo simulation proved that distribution of VTTS is right-skewed and thus under various conditions higher savings are possible. Particularly amount of passengers in vehicles positively influence value of savings. Another feature that was revealed from the analysis is that the worse condition of the base situation the higher will be the saving value after implementing of any kind of transport project. It means that under assumption that intensiveness on the newly built road will decrease at least at one percent, savings will increase significantly.

The policy implications corresponding to conducted research include improvement of the formula of VTTS assessment, as well as further research on other socio-economic effects, like increase in wealth of population, degree of economy stimulation with introduction of new transport projects, introduction of new job places not as temporary effect, but as long-term effect.

State and local authorities should also take into account possible extra measures, not directly connected to road reconstruction or building, but with stimulating population to switch from private vehicles to public transport. This requires profound investments into public transport system improvement and providing necessary conditions for people, like comfort, safety and speed. What one-way sensitive analysis showed is that principle parameters for savings growth are amount of people in cars and less important amount of people in buses. Thus stimulating measures for carpooling and car sharing can be also promoted and introduced.

The authorities also should increase public awareness of ecological externalities of using private car and take measures in order to decrease CO2 emissions and introduce, as it is done in London, congestion fees. Introducing new roads only stimulates population to buy cars and use them for even short distances instead of other modes of transportation. Negative stimulation is more effective in this case. Taking into considerations that level of automobilization keeps increasing in Russia, road networks are unable to follow amount of new cars and it will only lead to increase in level of congestion and worsening of ecological situation. As foreign practice shows, this also negatively impacts people's health, due to lack of physical activity, thus measures should be implemented, but gradually so that public does not react in a negative way.

Conclusions

Transport infrastructure plays a crucial role in socio-economic development of states and regions. The natural approach that the more transport projects are implemented the higher connectivity there is between various territories can only successfully be applied when there are no limits to access to financial resources. Unfortunately real situation is that governments are always limited in finance and have to choose between alternatives for the most efficient and effective option. When it comes to transport infrastructure, in most cases (unless public-private partnership is applied) it does not directly create profit for state. It can improve land-use conditions, stimulate economy development and improve social sphere on the surrounding territories. Consequently, alternatives cannot be compared by their NPV, IRR and other financial indicators which are commonly used in business projects. Most of them have negative values for commercial efficiency.

What does make difference is impact of transport project implementation on socio-economic situation and corresponding values of socio-economic effects. The stronger the effect the more attractive must be the project. The difficulty in this case is to carefully analyze effects and calculate them, because mistakes in assessment can lead to less efficient projects implementation.

The motivation of the research is to analyze currently existing area near Saint-Petersburg which requires profound investments in transport infrastructure and which cannot be implemented right away. There are several alternatives and regional administration has to decide on the most effective project which should be prioritized over other and implemented as fast as possible.

In order to provide recommendations for state authorities for a more detailed analysis of every transport project, the research was held in this sphere. The **goal** of the research was to introduce an improved approach for assessing values of travel time savings after implementation of transport projects. The following objectives took place in order to reach the set goal:

1. Analyze foreign VTTS (value of travel time savings) methodologies and collect information on what personal information about the users is taken into account when assessing transport projects effectiveness;
2. Analyze Russian methodology in order to understand what factors are included in the formula for VTTS assessment and what factors are omitted for which reasons;
3. Conduct survey in order to extract citizens' preferences on transportation mode choices;

4. Extract the most influential features for all groups of citizens and use them to construct logistic regression with binary choice of switching from car to public transport;
5. Update the existing formula with selected feature and test it by Monte-Carlo method;
6. Carry out a set of recommendations for the state authorities to improve the existing methodology and for local authorities to prioritize the projects to be implemented.

Within research framework primary data was collected, principal component analysis and cluster analysis were conducted. This allowed to get significant features for formula modification. The modified formula was tested with Monte-Carlo simulation with primer indicators corresponding to the current situation in Kudrovo. After Monte-Carlo simulation was held, one-way sensitivity analysis was conducted and introduced the most influential parameters of formula.

The research showed that comfort is one of the major factors that influence people's behavior and mode choice. The largest amount of respondents are ready to sacrifice their comfort in order to commute faster. It should be also taken into account that Kudrovo village undergoes challenge in transport infrastructure and it does not cover all the needs of inhabitants of this area. The results also showed that there is a group of respondents that are still ready to pay extra travel time for prestige and are not ready to switch modes of transportation in order to decrease travel time. This proves that people evaluate their time differently and that it depends on various factors.

Change in formula of VTTS assessment was a try to include an indirect coefficient of comfort, particularly load factor. As there is a direct connection between load factor of the road and people's feeling of comfort as well as economic efficiency of the road. Monte-Carlo simulation proved that distribution of VTTS is right-skewed and thus under various conditions higher savings are possible. Particularly amount of passengers in vehicles positively influence value of savings. Another feature that was revealed from the analysis is that the worse condition of the base situation the higher will be the saving value after implementing of any kind of transport project. It means that under assumption that intensiveness on the newly built road will decrease at least at one percent, savings will increase significantly.

Further research should include broader analysis of factors that influence comfort of passengers and influence of status of commuters. The current research does not show that there is a significant difference in commuting and leisure trips. Business trips and people who work on the road (drivers, couriers) are not taken into consideration. As foreign research widely uses differentiation of trips by their purpose, there might be still correlation in Russia.

There are several limitations of the research. First of all, data analysis was based on a small sample of residents of Kudrovo village. Socio-demographical situation in Kudrovo is not presented in official documents, thus structure of sample might not reflect the real structure of population. However, with 5% significance level it represents population by the size of the sample. This limitation is connected to lack of financial resources which does not allow to conduct survey with more respondents.

Another limitation is that it was based on a small territory of Kudrovo village on the border of Saint-Petersburg and the sample might not correspond to the whole Russian Federation. The particular feature of this ares is that transport infrastructure is almost absent there and people might have biased opinion on what should implemented on the area, compared to, for instance, population of Saint-Petersburg, Moscow or any other city with a better developed transport connectivity. Thus, tendencies that were revealed on this sample might not correspond to the regional and state level.

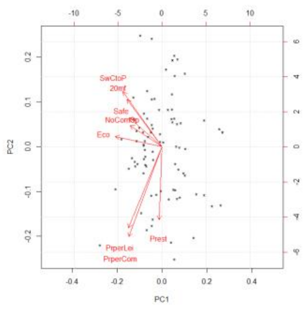
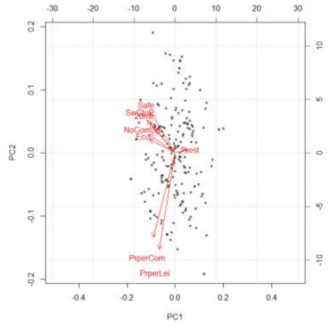
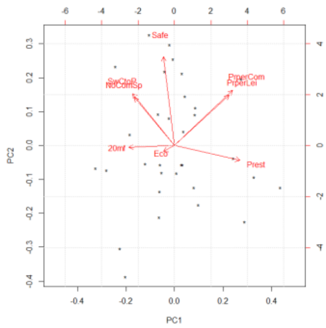
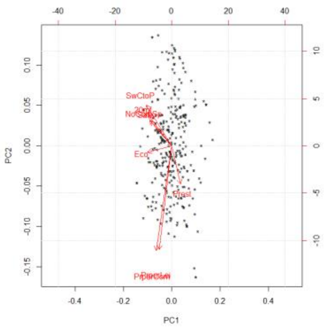
The last limitation is connected to the formula modification. The introduced coefficient does reflect the idea of comfort of passenger and its decrease in congested conditions. However, it does not reflect subjective attitude of people towards time pricing when wasting time in traffic jams. As a suggestion for further research it is advised to conduct an additional survey to reveal elasticity coefficient for population of Russian Federation, or one of its regions, for level of comfort during commuting and travel time.

Appendix 1. Questionnaire legend

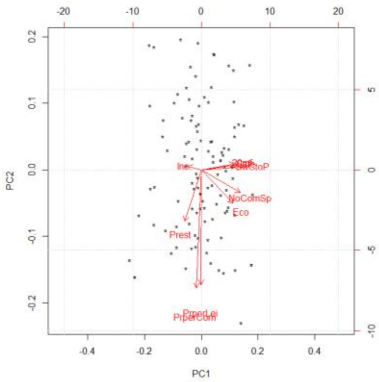
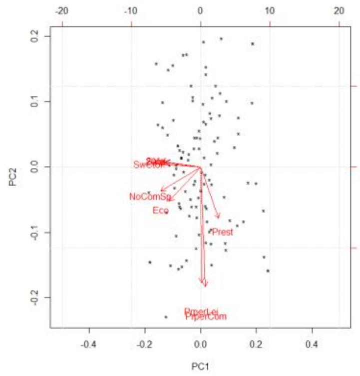
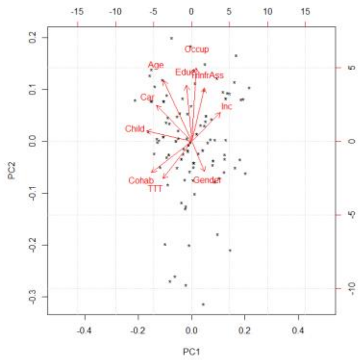
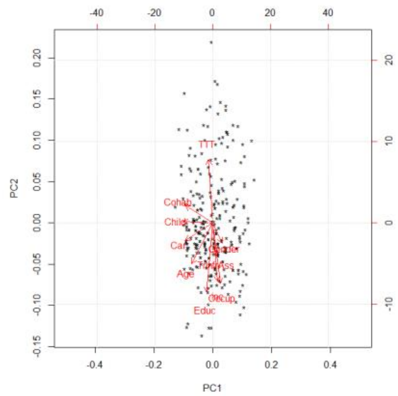
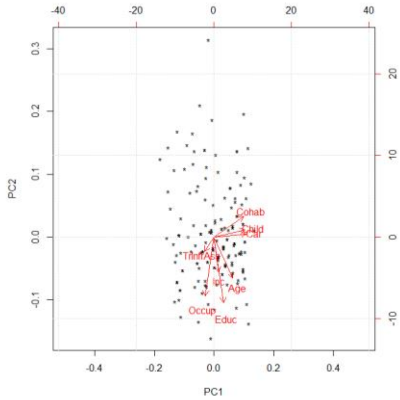
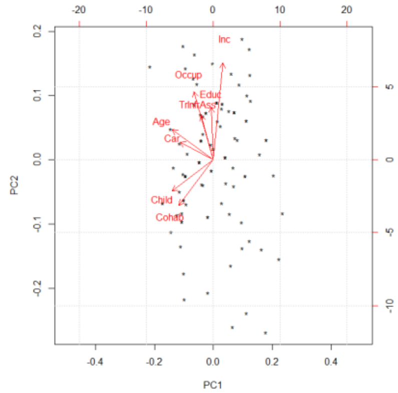
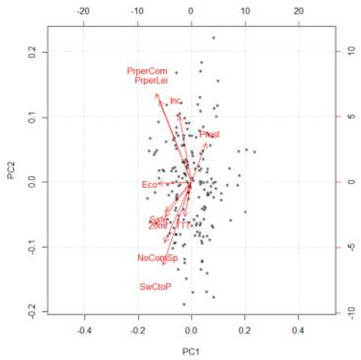
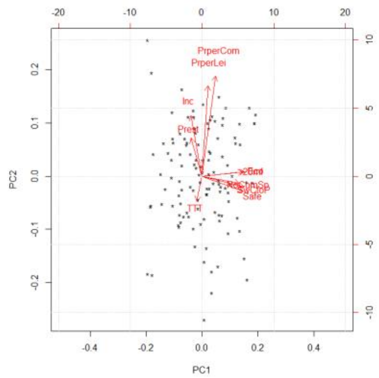
Variable	Description	Codes
ResofK	Resident of Kudrovo	0 - no, 1 - yes
Gender	Respondent's gender	0 - female, 1 - male
Age	Respondent's age	1 - 18-25 y.o.; 2 - 26-40 y.p.; 3 - 41-65 y.o.; 4 - elder than 65 y.o.
Educ	Education level	1 - primary school; 2 - secondary school; 3 - secondary vocational education; 4 - uncompleted higher education; 5 - higher education; 6 - PhD, second higher education
Cohab	Respondent's cohabitants	0 - lives alone; 1 - lives not alone
Child	Respondent's amount of children	0 - no, 1 - 1; 2 - 2 and more
Car	Car ownership	0 - no car; 1 - yes, uses mostly per commuting to work; 2 - yes, uses mostly per leisure
Occup	Occupation	0 - no work; 1- student; 2 - pensioneer; 3 - yes, works in SPb or Leningrad region; 4 - yes, works in Kudrovo
Inc	Income	1 - very low; 2 - low; 3 - middle; 4 - high; 5 - very high
TrInfAss	Respondent's attitude towards transport infrastructure in Kudrovo	0 - hard to say; 1- terrible; 2 - bad; 3 - good;
TTT	Time spent on entering/leaving Kudrovo	1 - 10-30 min; 2 - 30 min - 1 hour; 3 - 1 hour - 1,5 hours; 4 - more than 1,5 hours
SwCtoP	Are you ready to switch from personal car to public transport if it saves you 20 min out of 1 hour trip? (40 min instead of 60 min)	1- definitely not; 2 - probably not; 3 - hard to say; 4 - probably yes; 5 - definitely yes
Safe	Are you ready to spend extra 15 minutes per trip but to be able to read books, watch videos, make business calls in a safer mode of transportation?	1- definitely not; 2 - probably not; 3 - hard to say; 4 - probably yes; 5 - definitely yes
NoComSp	Are you ready to commute in overcrowded metro if it saves you up to 50% of time (30 min instead of 1 hour)?	1- definitely not; 2 - probably not; 3 - hard to say; 4 - probably yes; 5 - definitely yes
20mf	Are you ready to walk 20 min to the closest transport?	1- definitely not; 2 - probably not; 3 - hard to say; 4 - probably yes; 5 - definitely yes
PrperCom	Are you ready to pay double price if it saves you half of time per commuting? (30 min instead of 60 min)	1- definitely not; 2 - probably not; 3 - hard to say; 4 - probably yes; 5 - definitely yes
PrperLei	Are you ready to pay double price if it saves you half of	1- definitely not; 2 - probably not; 3 - hard to say; 4 - probably yes; 5 - definitely yes

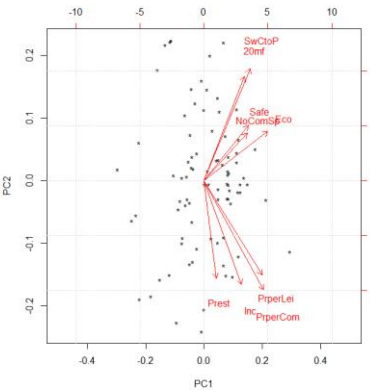
	time per leisure purpose trips? (30 min instead of 60 min)	
Eco	Are you ready to spend extra 15 min if you use ecologically friendly mode of transportation?	1- definitely not; 2 - probably not; 3 - hard to say; 4 - probably yes; 5 - definitely yes
Prest	Are you ready to spend extra 30 min (1,5 hours instead of 1 hour) but use a prestigious mode of transportation?	1- definitely not; 2 - probably not; 3 - hard to say; 4 - probably yes; 5 - definitely yes

Appendix 2. Principal Component Analysis results

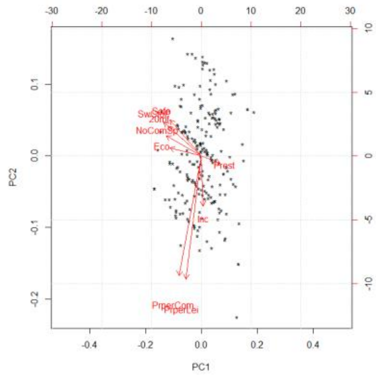
Low income preferences 	Middle income preferences 
High income preferences 	All respondents preferences 

Income + Preferences of 109 observations	Preferences 109 observations

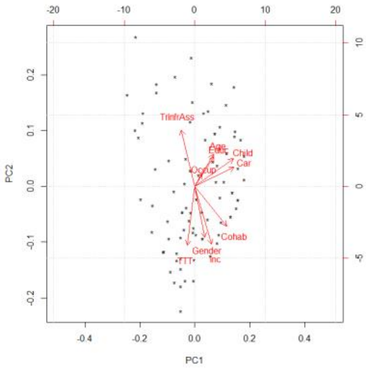
	
Socio-demography 109 observations	Socio-demography 305 obs
	
Females socio demography	Males socio demography
	
Females preferences + income	Males preferences + income
	
Very low/low income preference	Middle/high income preference



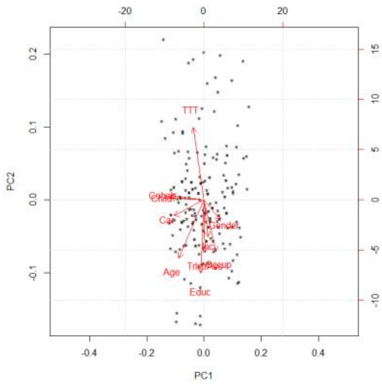
Very low/low income socio demographic



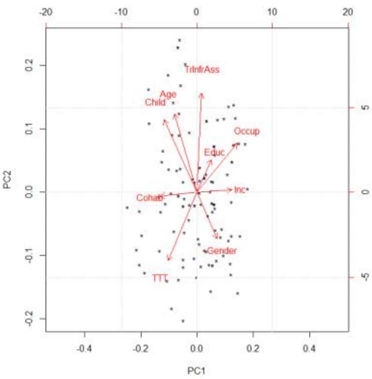
Middle/high income socio-demography



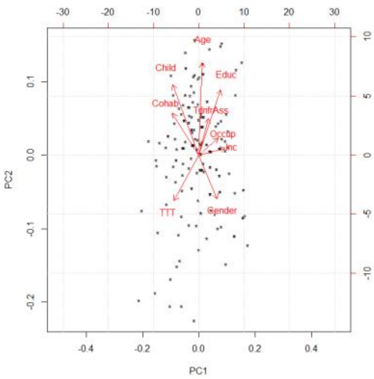
No car socio demography



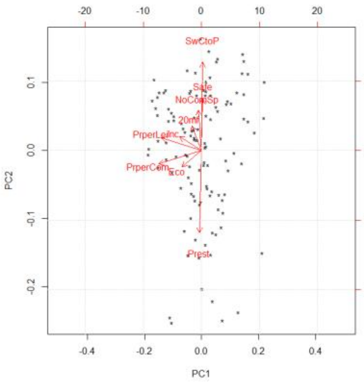
Have car socio-demography



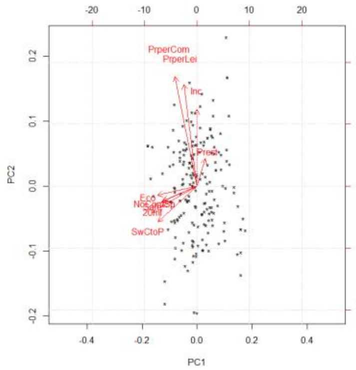
No car preferences



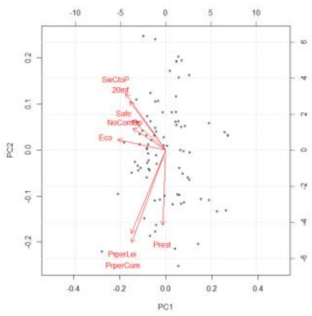
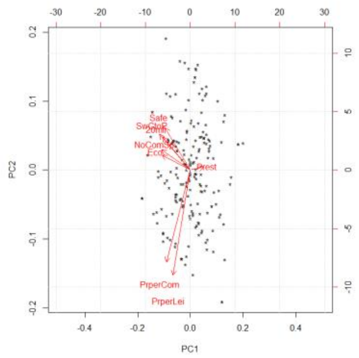
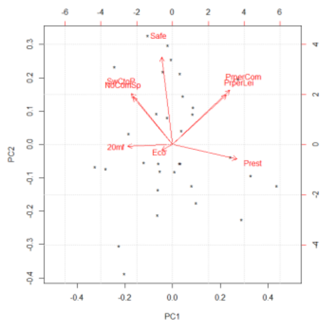
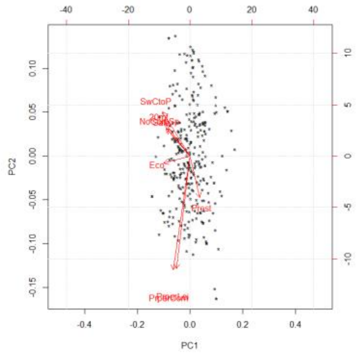
Have car preferences



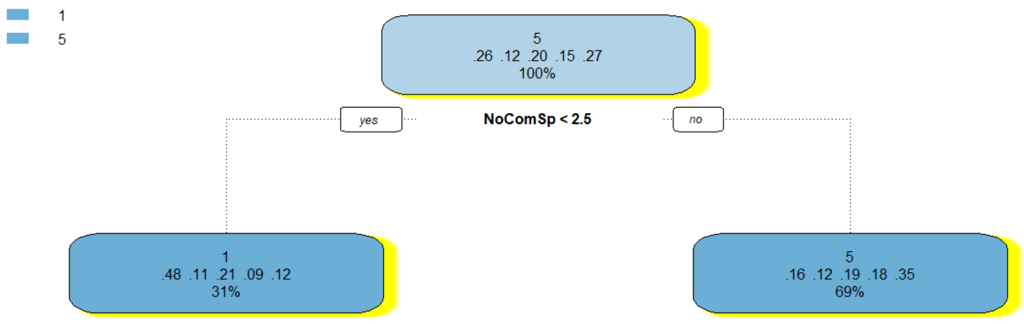
Low income preferences



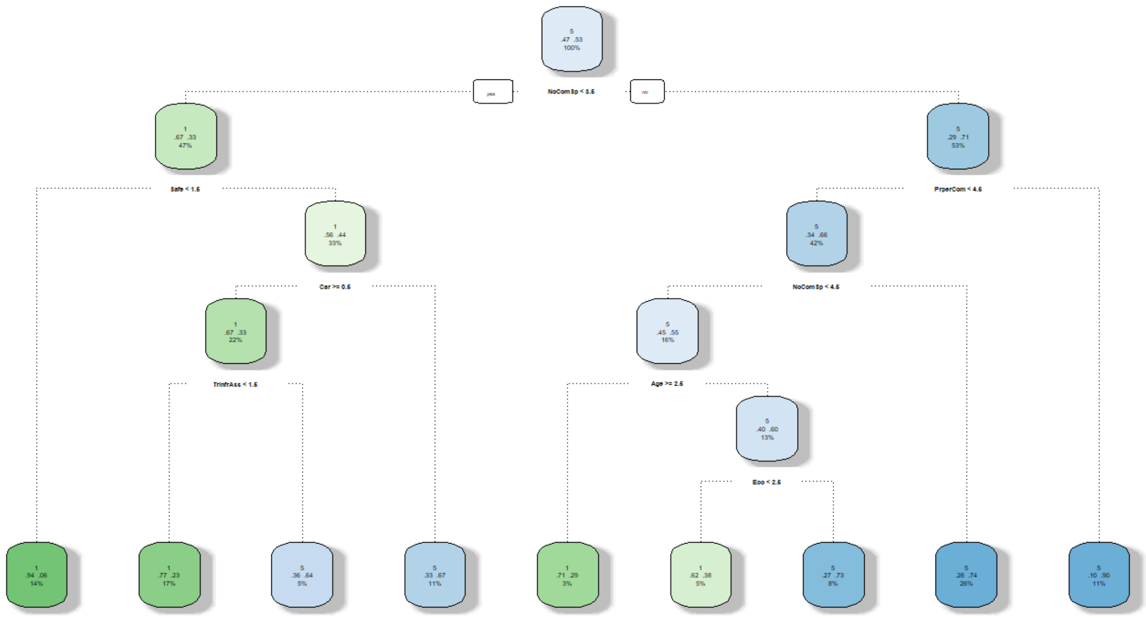
Middle income preferences

	
High income preferences 	All respondents preferences 

Appendix 3. Cluster analysis results



Result of cluster analysis. Willingness to switch from private car to public transport is chosen as factor. Initially there are 5 levels. Two classes are formed: definitely not = 1, definitely yes =5. The decision tree chose as the most influential factor – willingness to commute in overcrowded subway twice faster than in base conditions. Thus, speed over comfort in Kudrovo plays crucial role.



Sample is reformed: two levels are created: definitely not + not = 1, definitely yes + yes = 5. Doubt to say – 3 is deleted from the sample.

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